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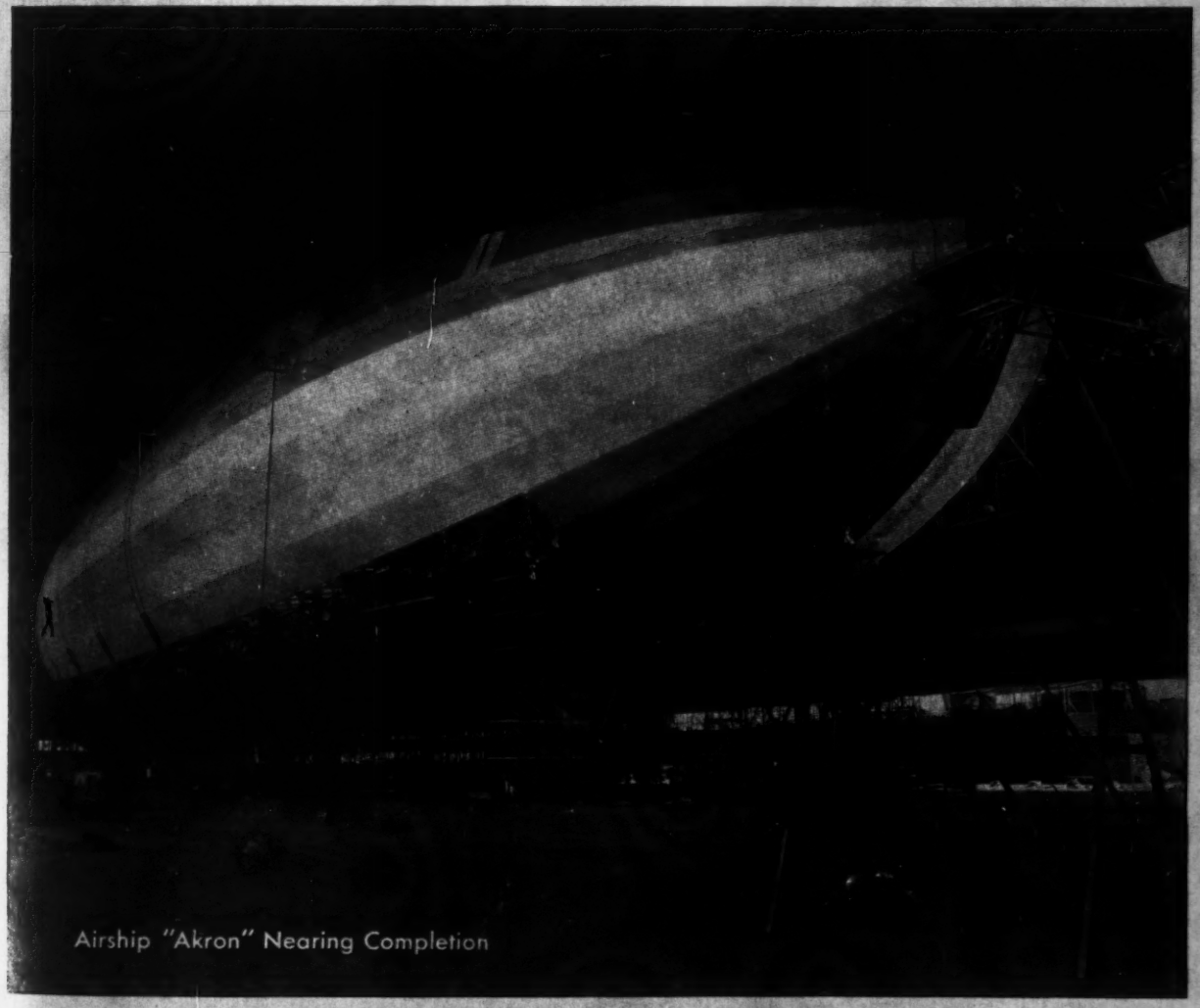

Airship "Akron" Nearing Completion

August 1931

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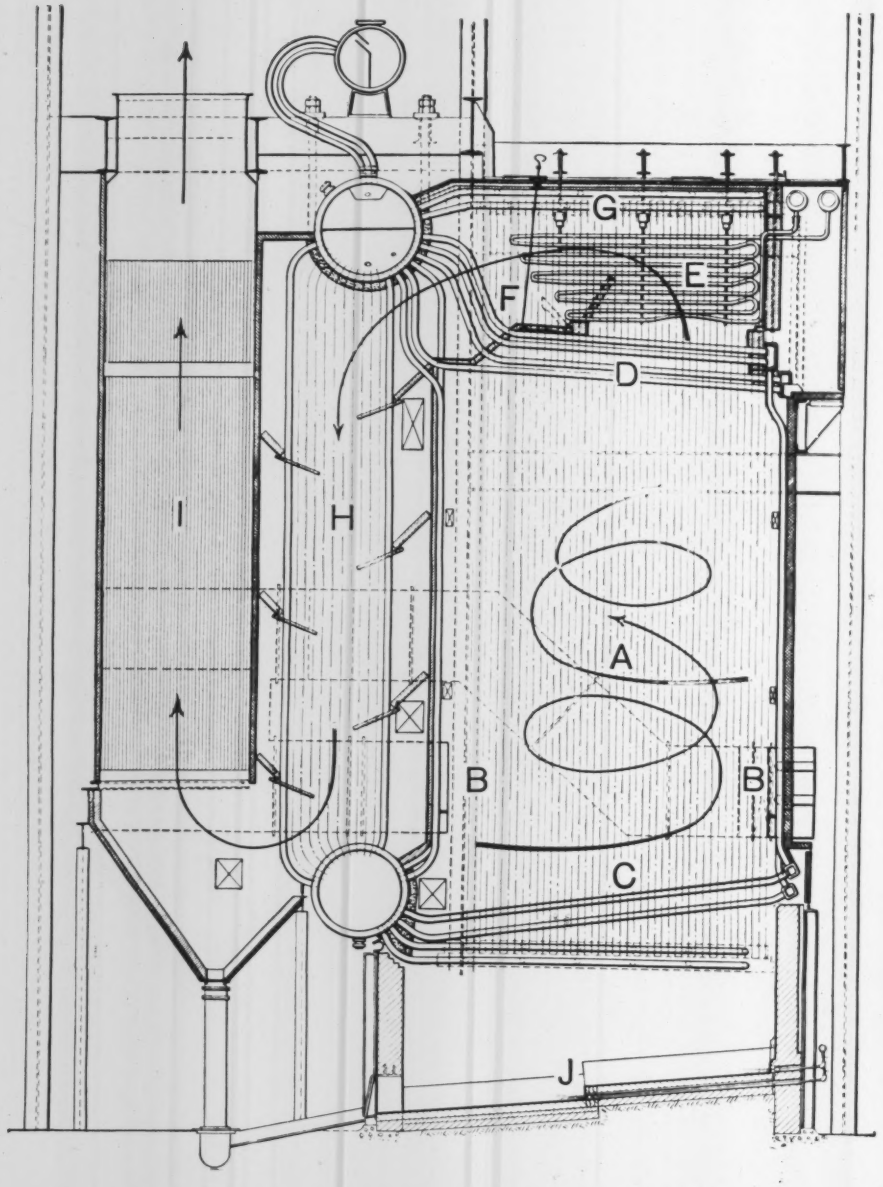

A - Brickless furnace...bare-tube furnace walls...no external risers or downcomers

B - Fuel and air inlets for corner firing

C - Ash pit "water screen"

D - Superheater screen

E - Superheater

F - Bypass damper for regulating temperature of superheated steam

G - Roof tubes

H - Convection bank

I - Plate air preheater

J - Sluicing ash discharge and conveyor

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What It's All About

THE COVER PICTURE shows the new Navy dirigible nearing completion at Akron, Ohio. It is used in connection with this month's leading article.

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SOME RECENT ASPECTS OF RIGID AIRSHIPS are discussed by Lieutenant Settle in the leading article of the August issue of MECHANICAL ENGINEERING. Sometime in the near future the United States Navy's new dirigible *Akron* will leave the enormous dock in which she is now under construction in the city that bears her name and will undergo her first trials. Impressive successes and failures of airships have sharply divided public opinion here and abroad as to the practicability of the rigid airship. When the *Akron* is launched there will be much controversy and conversation on this subject and much interest in the technical features of the new ship. Lieutenant Settle describes some of the more important details of the *Akron* and compares it with the other large recent ships of similar type, the *Los Angeles*, the *Graf Zeppelin*, the *R-100*, and the late *R-101*.

:: :: ::

AN INTERNATIONAL SYSTEM OF FITS, with allowances and tolerances for cylindrical parts and limit gages, is under consideration by the International Standards Association. The proposed internationally uniform standard is reported and discussed by John Gaillard of the A.S.A. in the August issue of MECHANICAL ENGINEERING. Because of the importance of the subject to engineers and manufacturers all over the world, attention is emphatically directed to the present proposal. Those whose interests are at stake should not fail to give early and careful study to Mr. Gaillard's report which is at present receiving wide consideration. Constructive suggestions are, of course, in order.

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RECENT AIRCRAFT ENGINEERING RESEARCH was reported last May to the aeronautical industry at the Langley Field Conference of the National Advisory Committee for Aeronautics. A representative of MECHANICAL ENGINEERING, Prof. Alexander Klemin, of New York University, attended the Conference and has prepared a summary of it which appears in the August issue. Professor Klemin's report affords an opportunity for those who did not attend the Conference to learn what the N.A.C.A. is doing and thinking about.

:: :: ::

DEVELOPMENT OF SEMI-AUTOMATIC RIFLES has been going on for more than a quarter of a century. The Small Arms Division, Manufacturing Service, of the U. S. Army Ordnance Department has been pushing this development and several promising models have been brought out. A paper sketching the history and describing the present status of the semi-automatic rifle that will eject the case of a fired cartridge and reload itself with a fresh cartridge has been prepared especially for MECHANICAL ENGINEERING by Maj. Julian S. Hatcher, of the Ordnance Department. Two types of such rifles, the Garand and the Pedersen, are described and illustrated.

:: :: ::

PATENT APPEALS IN THE UNITED STATES are at present made to any one of ten Circuit Courts of Appeals. Each circuit court is entirely independent of the others and may, and frequently does, decide oppositely. A patent adjudicated oppositely in two separate circuit courts may be referred to the Supreme Court for final decision, with consequent delay and expense. Such a condition leads to grave uncertainties and shocking economic waste. There is therefore proposed a single court to take over the final jurisdiction of patent appeals from the present 10 circuit courts. In an article in the August issue of MECHANICAL ENGINEERING, Edwin J. Prindle, to whom the country owes much for his effective work for patent procedure reform, describes the present condition of affairs and the proposed changes. The bill he has drafted to put his proposal into the law is also quoted. Discussion of Mr. Prindle's proposal is solicited.

:: :: ::

THE SCOPE OF MANAGEMENT IN OUR FUTURE BUSINESS DEVELOPMENT appears to be boundless to J. P. Jordan who writes on this subject in the August issue of MECHANICAL ENGINEERING. Mr. Jordan proposes the answers to the following questions: What is good management? What is the real duty of management in each individual company? What is the real duty of the management of each company with respect to the industry of which it is a part?

MECHANICAL ENGINEERING

Volume 53 August, 1931 No. 8

Some Recent Aspects of Rigid Airships

Particulars Regarding the Zeppelin Type of Metal-Structure, Fabric-Covered, Rigid Airship and Its British and American Derivatives, With Special Reference to the Structure, Outer Cover, Gas Cells, Lifting Gases, Engines, Power Transmissions, and Fuels, and to the Naval and Commercial Roles of Airships

By T. G. W. SETTLE,[1] AKRON, OHIO

THE word "recent" in the title of this paper is susceptible of wide variation in interpretation, but will be arbitrarily defined for our present use as meaning the airship "era" commencing with the *Graf Zeppelin* in Germany, the *R-100* and *R-101* in Britain, and the *Akron* and her yet unnamed sister-ship, the *ZRS-5*, in this country. Although the period as thus defined dates back to 1926, or earlier, it can justly be called recent, it is believed, in view of the more than thirty years during which men have been building and flying rigid airships, and the one hundred and fifty years during which men have been "sailing" and navigating the fundamental lighter-than-air vessel, the engineless airship—the free balloon.

The author will confine himself to a consideration of the Zeppelin type of metal-structure, fabric-covered rigid airship, and its British and American derivatives. The so-called "metalclad" airship, a metal-covered pressure type, is a most interesting development, but has not yet been built in a moderate or large size, and differs in fundamental operating characteristics from the Zeppelin type in that internal gas pressure is necessarily maintained in order that the hull may carry the aerodynamic loads imposed at all but low air speeds. By the term "airship" in what follows is meant the large, rigid airship.

BEVEL-GEAR HOUSING AND PROPELLER FOR U.S.S. "AKRON," ON TEST STAND, AKRON, SEPTEMBER, 1930. PROPELLER SHOWN IN POSITION FOR VERTICAL THRUST

(Dr. Karl Arnstein, designer of the "Akron," and Chief Engineer of Goodyear-Zeppelin Corp., and the author, Lt. Settle, U.S.N. Navy Inspector, on the ground. Dr. Wolfgang Klemperer, noted glider pilot and chief of the research section of Goodyear-Zeppelin, standing on outrigger.)

At the beginning it is desired to point out a basic conception of the airship as essentially a sea-going vessel, the counterpart in the air of the surface ocean-going vessel. The airship's proper realm is the wide, open spaces of the oceans, and not over continents or along continental coasts. Both for naval and commercial use the airship is a "high-seas" vessel.

Before going on to the consideration of the various features of the airship, a few comparative figures on some of the latest vessels may not be amiss, in particular, those on the *Akron* and the *Los Angeles*.

	Los Angeles	*Akron*
Air displacement, cu. ft.	2,470,000	6,500,000
Length, ft.	658	785
Beam, ft.	91	133
Gross lift, tons	77	202
Useful lift, tons	30	91
Full speed, knots	63	72.2
Cruising range at 50 knots, in nautical miles	3,500	9,180

[1] Lieutenant, U.S.N., Inspector of Naval Aircraft, Goodyear-Zeppelin Corporation.

Presented at a meeting of the Buffalo Section of the A.S.M.E., Buffalo, N. Y., February 17, 1931. Abridged.

The *Graf Zeppelin* is intermediate in displacement between the *Los Angeles* and the *Akron*, having one of 3,700,000 cu. ft. The two British ships, *R-100* and *R-101*, were built as 5,000,000-cu. ft. vessels, but the *R-101* was lengthened to displace 5,500,000 cu. ft.

THE STRUCTURE AND OUTER COVER

The modern American and British airships all fall within the general classification of Zeppelin-type ships when this type is defined simply as that of vessels with metallic hulls built up of transverse framing and longitudinal girders, stiffened with wiring, hull covered with fabric, and gas contained in internal cells, the vessels not using internal gas pressure for any part of their strength.

However, when the Zeppelin is defined in a more narrow sense as being the type of detailed structure exemplified by past Zeppelins and by the famous *Graf Zeppelin*, then we find the modern British and American designs diverging sharply in many details from this strictly German Zeppelin practice. We actually have before us now, four derivatives of the generic Zeppelin type, these being, respectively, the *Graf Zeppelin*, the *R-100*, the *R-101*, and the American design (that is, the *ZRS-4* and *-5*).

The German Zeppelin Company has kept very close to its past practice in structural design, both in the *Graf Zeppelin*, a 3,700,000-cu. ft. vessel, and, it is believed, in their new ship, the 129th German Zeppelin, which will shortly be laid down in Friedrichshafen and which, according to press accounts, will displace over 7,000,000 cu. ft. This conventional design is a structure composed of transverse polygonal frames (main and intermediate) and longitudinal girders connecting the apexes of the frame polygons, all of duralumin; the main frames are braced and stiffened by radial and chordal transverse steel wiring, which wiring has the additional function of forming the bulkheads or boundaries between adjacent gas cells. The intermediate frames are of relatively light girders without transverse wiring. At the bottom of the ship is the keel, a large triangular-section, built-up longitudinal member, which, just as in the case of the keel of a surface vessel, is the "backbone" of the ship. The keel furthermore furnishes the local strength necessary for the storage of fuel, ballast, naval and commercial loads, and officers' and crew's quarters, and forms the fore-and-aft gangway of the vessel. Two systems of steel wiring are built in the hull skin structure, the outer system being the shear wires and the inner, the gas-cell netting wiring. The shear wires stiffen up the structure as a whole and take shear loads; the shear wires run diagonally between joints of frames and longitudinals. The gas-cell netting, as the name implies, takes the pressure of the cell fabric and transmits the resultant loads to the structure at the joints.

Many parts of an airship have one or more secondary reasons for their existence. For instance, the gas-cell netting assists, secondarily, in taking shear loads; the shear wires assist in supporting the outer cover; the taut outer cover itself adds appreciably to the general strength of the structure.

The conventional German duralumin girder is of triangular section, with channels at the apexes connected by diagonal crossed lattices riveted to the channels. Joints are made with the aid of gusset plates.

The British 5,000,000-cu. ft. ships, the *R-100* and *R-101*, represent two separate departures from the "standard" Zeppelin design. Some of the details of divergence are important, and the divergences radical.

The hull structures of both of these ships are without intermediate transverse frames, and there are relatively few longitudinals, only sixteen in the *R-100* and fifteen in the *R-101*, compared to thirty-six in the *Akron*. The British construction permits a very efficient primary structure to be built, using girders of sufficient size to have a high strength/weight ratio; but the large resultant sizes of their outer-cover panels, between adjacent pairs of frames and longitudinals, introduce difficulties in connection with the cover.

The *R-100* shows probably the fewer divergences of the two from Zeppelin practice; this ship is a duralumin-girder, steel-wire-braced vessel. Her girders are enormous by comparison with the Zeppelin type and are of triangular section with tubular booms; the booms are formed by spirally winding strip sheet duralumin, and riveting the spiral seam. The lattice members are perforated-channel box girders, much like the new American type.

The girders of the *R-101* were of much larger sections than those of the *Graf Zeppelin*, but were smaller than those of the *R-100*, and were of triangular section with stainless-steel tubular booms and duralumin cross-struts. Diagonal steel tie rods stiffened the girder. The structural joints of the *R-100* are made with spiders and screw threads, allowing some adjustment at erection. On the other hand, the joints of the *R-101* were all pinned, with no possibility of adjustment. This necessitated extremely accurate shopwork, involving geometrical calculations accurate to 15 significant figures.

Our two new Navy ships, building at Akron, represent another, and probably the greatest, divergence from old Zeppelin practice in structure. Their main frames, instead of being stiffened by transverse wiring, will be of a triangular "deep section" type, inherently rigid of themselves, without transverse structural wiring. (The British *R-101* had deep main frames.)

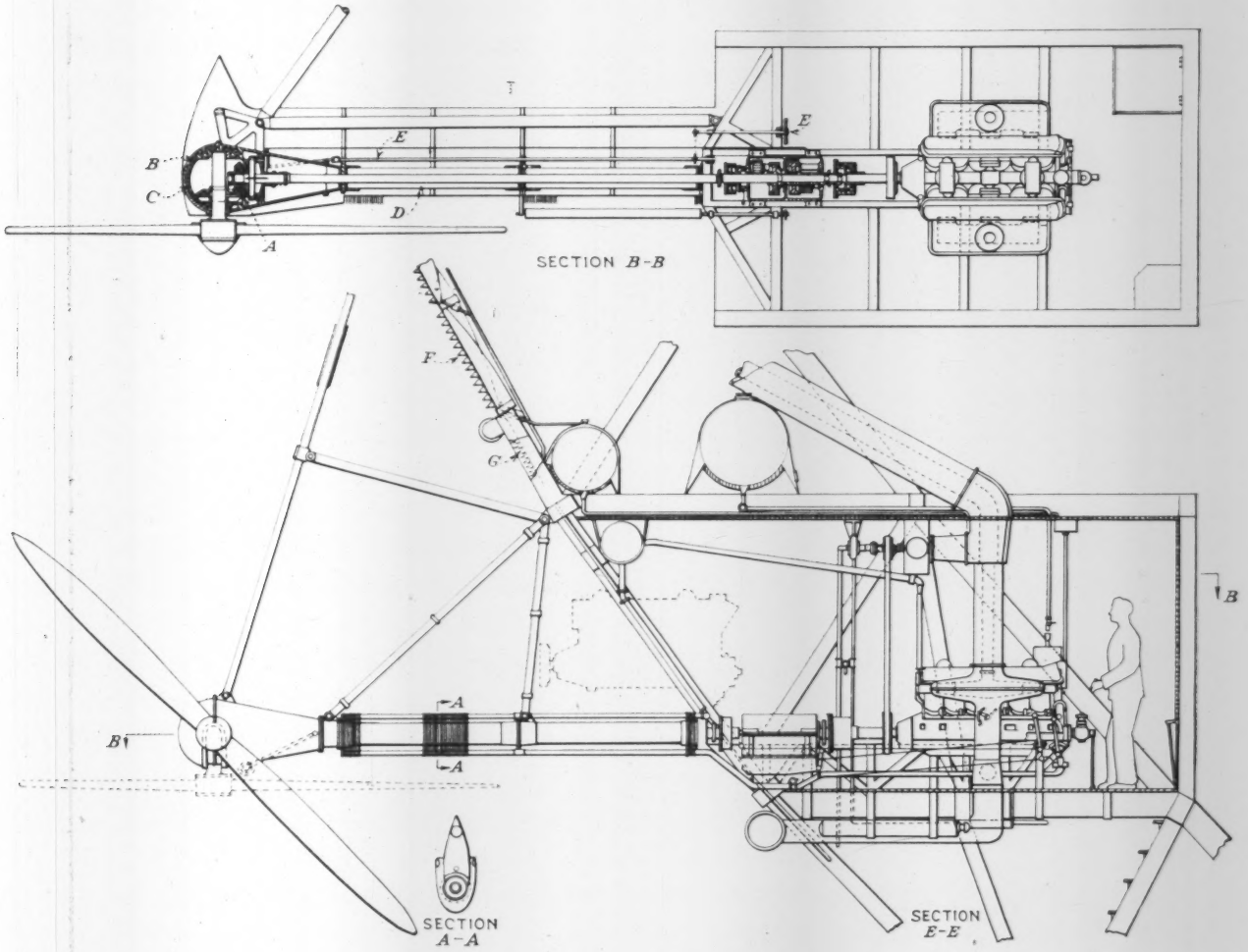
These main frames have the apex of their triangular section inboard, and are built up from duralumin box girders, with punched channels forming the girder sides. The main frames will be braced with diagonal steel rods or wires on their peripheral faces, at the skin of the ship. The deep section of these main frames, in addition to other advantages, allows access to the crew all around the vessel.

A steel-wire-netting bulkhead will be placed in each main frame, and will be anchored to alternate inner-ring joints of the frame through resiliency devices. This, however, is solely a bulkhead between cells and

is not at all a structural or frame-stiffening device. The resiliency devices through which the bulkheads are secured to the frame joints are piston-cylinder devices, charged to several hundred pounds pressure with helium. In the event of a deflated cell, its boundary bulkheads will belly well into the deflated bay, because of the slackness allowed by these resiliency cylinders, and local structural loadings in this emergency will therefore be

and equator. These three gangways add greatly to the longitudinal strength of the vessel, and facilitate accessibility to all parts of the ship.

One of the most radical features of our new ships will be the inside engine rooms. On all past Zeppelins the engines have been housed in power cars which were held in place outside the hull by struts and cables. The *Graf Zeppelin* has, and *R-101* had, five such power



ONE OF THE EIGHT POWER PLANTS AND SWIVELING PROPELLERS

(Directly reversible engines are installed in separate engine rooms inside the hull and connected through rigid drive shafts and bevel gears (*A*) to the propellers. Thus, the propellers can be used for both ahead and astern thrust and, by tilting their axes through 90 deg., also for vertical thrust. The swiveling device is mounted in an inner spherical case (*B*) inside an outer case (*C*) which is rigidly attached to the hull by a braced outrigger (*D*). The inner case can be turned through a quarter of a circle by a worm driven by a rod (*E*) extending into the engine room, and carries the propeller with it. A locking clutch engaging the inner housing holds the propeller shaft in any position. The lineshaft can be disengaged from the engine to slow down the propeller before changing its direction of thrust. A system of water recovery counterbalances the loss of weight from liquid-fuel consumption, and includes longitudinally ribbed condensers (*F*) extending up the side of the ship, and water separators (*G*) below the condensers.)

greatly minimized compared with those which would be involved with the Zeppelin type of structurally wired bulkhead.

The American ships have light intermediate frames—three of them between each pair of main frames in the midship section.

The next big divergence of the American ships is that they will each have three fore-and-aft keels or gangways instead of one, and these will be located one on top and one on each side at the 45-deg. point between the bottom

cars, each car containing one engine. The *R-100* has three power cars with two engines each, one a tractor and one a pusher. The number and arrangement of the power cars on the *LZ-129*, the new German ship, are still in doubt. The fact that our new ships are to use helium as the lifting medium made it possible, from the fire-hazard viewpoint, to place the engines inside the hull. The extremely strong points in the ship's structure at the intersections of the deep main frames and the side keels or gangways, seemed to invite the de-

signers to place the engines within the ship at those points. Of course, the elimination of the outboard power cars saves the large penalty which such cars exact in aerodynamic drag, and consequently in power and speed.

A noteworthy advance has been made in the past decade in quality and performance of duralumin. In building the *Shenandoah* in 1921–1923, the Navy Department specified a minimum yield point in tension of 30,000 lb. per sq. in., while in the present contract with the Goodyear-Zeppelin Corporation for the two Navy ships the corresponding specified figure is 42,000 lb. per sq. in. In both instances the material actually used surpassed the specified minima.

The matter of protecting the structure from corrosion has also made great progress. The *Los Angeles* originally had no structural corrosion prevention whatever. The *Akron* and *ZRS-5* will have all of their structure very adequately protected; all the duralumin is anodized prior to its fabrication into girders; even the duralumin rivets (of which there are about 6.5 million in a ship) are anodized. Then, on top of the anodization, all girders are varnished with aluminum-pigmented varnish. All steel wiring is bruntinized; all steel parts are cadmium plated. Stainless steel is used in valves and pipe fittings.

In the *R-100*, the tubular duralumin girder booms are protected inside and out against corrosion by a sort of greasy varnish. Furthermore the inside of these booms can be inspected with the help of a special optical device inserted through plug holes.

The box-girder construction used by the Goodyear-Zeppelin Corporation represents a large advance over the triangular latticed girder from the point of view of mass production and shop practice.

Modern airships, as far as "brute strength" goes, are probably several fold stronger than the wartime Zeppelins. One factor contributing to this is, of course, the smaller fineness ratios of modern ships. However, when one considers the punishment to which many of these old war Zeppelins were subjected without "sinking" them, we must indeed wonder whether modern airships are not relatively more "seaworthy" and invulnerable than the slow and cumbersome surface vessels.

It is believed to be safe to predict that in the ever larger-displacement airships of the future, and following the lead of the British, stainless steel will be more and more used for the major-strength and highly loaded elements. Duralumin will always be used, undoubtedly, for secondary structure. One may expect to see an increasing use of the super-light magnesium alloys for certain minor structure and fittings.

Airships have been and undoubtedly will continue for a long time to be fabric covered. As in every other branch of industry and science, advancement is constantly being made in materials and methods. We have better fabrics at our disposal today for airship outer covers than we did ten years ago, and methods of fabrication and installation are improved over those of war days.

German and American practice as to installation is to keep the rectangular or trapezoidal fabric panels between adjacent pairs of frames and longitudinals to a reasonably small size, and to support the cover in these panels by tying to wires. A cover panel is laced taut to the girders forming the boundaries of the panel, and then is doped in place and thereby further tautened. Sealing strips are doped on over the lacings, and the result is a taut, durable, light-weight metallized fair surface. To give an idea of the durability of such a fabric cover, it may be said that the *Los Angeles* retained 75 per cent of her original German cover on board for seven years.

The *Akron* will use over 35,000 sq. yd. of cotton fabric, weighing 2.8 oz. per sq. yd., for its cover, which will weigh in all over three tons. The fabric has a breaking strength of 60 lb. per 1 in. width of strip in both warp and fill, and this strength is increased still more after doping. Four coats of dope are applied, the first two clear, and the last two with aluminum pigment.

Laymen usually ask, "Why not use metal covering?" The answer is that metal is far too heavy, too weak against tearing, lacks resiliency, is not durable enough (corrosion), and is too difficult to install, maintain, and repair. However, the future may see certain limited areas of an airship's surface covered with metal.

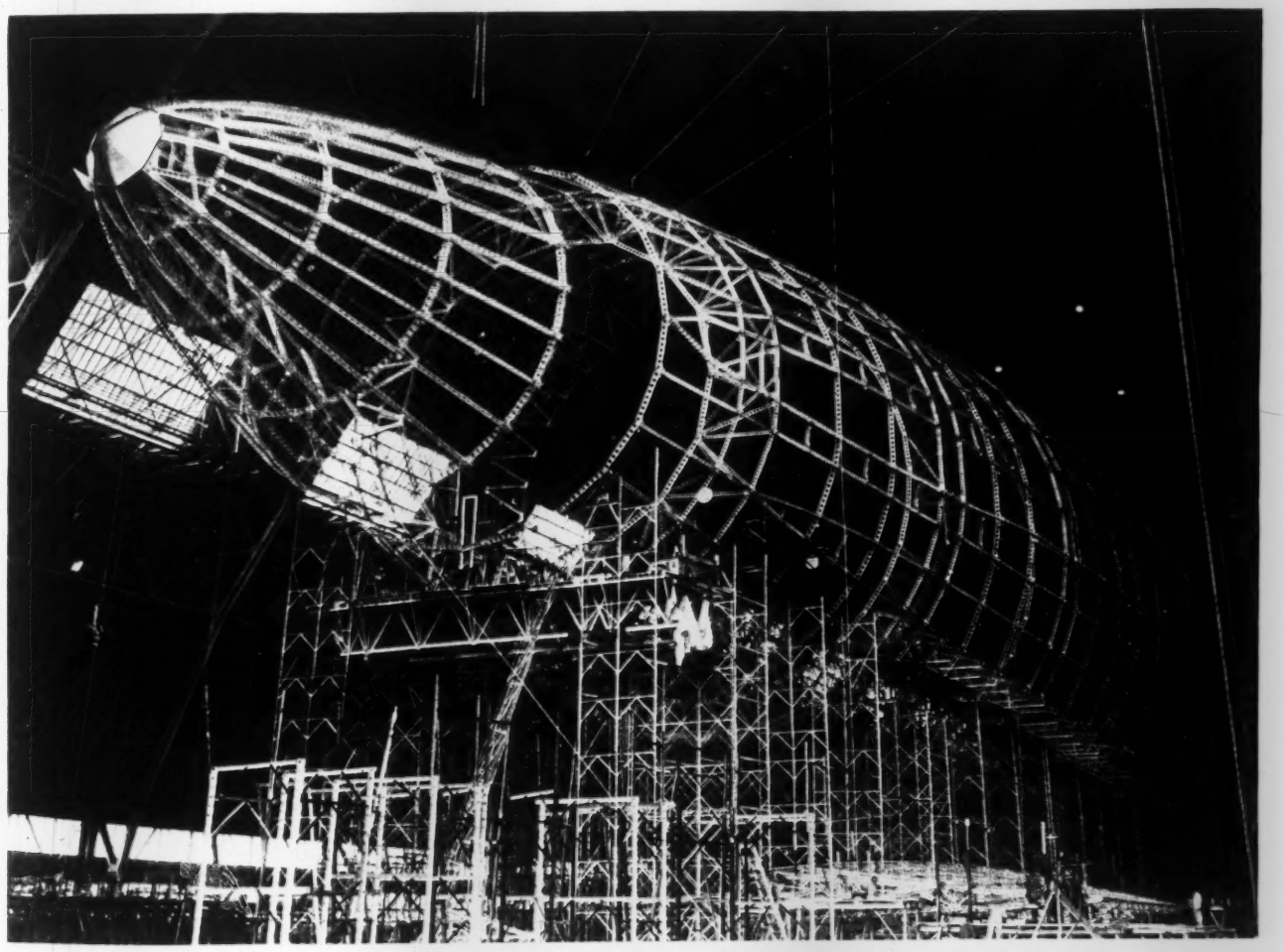
It is significant that of the 115 airships built by the German Zeppelin Company, not a single vessel has suffered a major casualty because of outer-cover trouble.

Gas Cells and Lifting Gases

Until the last several years in this country, and up until the present in foreign countries, the only satisfactory gas-cell fabric which had been evolved was the so-called "goldbeater's-skin fabric." This fabric is composed of four elements: (1) the outer light cotton cloth for strength, (2) the inner layer of goldbeater's skins constituting the gas-containing element, (3) the adhesive material binding the skins to the cloth, and (4) waterproofing varnish or paraffin. Goldbeater's-skin fabric has been a very satisfactory cell fabric in the past, but has the disadvantages of being costly and tedious to manufacture (all skins have to be laid by hand), and is susceptible to humidity conditions and liable to damage while handling in any but moist air; dry air quickly stiffens up the fabric and makes it brittle.

For many years several agencies in this country have been working on the problem of producing a cell-fabric substitute. During 1929 the Goodyear-Zeppelin Corporation, in collaboration with the Navy, developed the so-called "gelatin-latex fabric" and two experimental cells of this material were installed in the *Los Angeles* early in 1930 for test. This fabric is the usual light-cotton-cloth base, on which are spread mechanically many layers of gelatin and rubber latex. It is equal or superior to goldbeater's-skin fabric in all respects, except weight, being slightly heavier. The *Akron* will initially have half her cells of rubberized fabric and the other half of gelatin-latex.

The two lifting gases for airships are hydrogen and helium. Our Navy airships are the only Zeppelins to date which have utilized the non-inflammable and non-explosive helium, of which, fortunately, this country at present has a world monopoly. While it is felt that hydrogen is amply safe when used by fully experienced airship crews, nevertheless the use of helium removes all possibility of a conflagration such as followed the grounding of the *R-101*. This is a major consideration for merchant airship lines. Dr. Eckener has announced to the press that the *LZ-129* will be a helium ship. It is predicted that all future merchant airships will use helium. It is understood that certain agencies are attempting to find some substance which could be added to hydrogen to render it inert without altering its lift characteristics, much on the same idea that tetra-ethyl lead minimizes detonation in motor fuels.



AFTER END OF U.S.S. "AKRON," MARCH, 1931. STERN CONE BEING CONNECTED UP TO REMAINDER OF SHIP

ENGINES

While airships have a background of thirty years, hundreds of ships, tens of thousands of passengers carried commercially without casualty, hundreds of thousands of miles flown commercially and on naval missions, hundreds of tons of mail and cargo carried commercially, and while three of the great nations have been actively developing them during one to three decades, and two other nations have been less actively interested—yet with all of this experience and development, we have in the world today only one airship engine, only one fully developed and tried power plant for these vessels. This is the engine built by Maybach, a subsidiary of the German Zeppelin Company.

The Maybach engine of the latest model which will be used in the *Akron*, and which is now installed in the *Graf Zeppelin*, is a 12-cylinder, 60-deg. Vee, gasoline or fuel-gas, water-cooled engine, of 560 hp. rating at 1600 r.p.m., having a 7 to 1 compression ratio, and weighing about 2500 lb. dry. It is a wholly internally reversible engine, this feature being obtained by having two sets of cams on the single camshaft, an ahead set and an astern set; to reverse, the camshaft is shifted longitudinally to bring the other set of cams under the cam followers. All bearings in the engine are anti-friction, the highly loaded ones such as the main crankshaft and connecting-rod bearings being of the roller type. All cranks are counterweighted. The specific fuel con-

sumption is under 0.45 lb. per hp-hr.—and low specific fuel consumption is more important than low engine weight in an airship engine. Maybach engines are run for thousands of hours between major overhauls.

It is felt very strongly that the compression-ignition heavy-oil engine, is the type destined eventually to become "the" airship engine. The fundamental reasons for this are the greater safety from fire hazard and the much better specific fuel economy possible with heavy-oil fuel. The task of evolving the airship Diesel from past types of this engine is largely one of (*a*) producing satisfactory solid-fuel injection at high engine speeds, and (*b*) reducing all weights without sacrificing reliability and fuel economy. Slow-speed solid-injection Diesel engines have for some years been common, while relatively high-speed air-injection Diesels have been feasible for some time. Air injection is impracticable in an airship engine principally because of weight, and high speeds are essential—that is, speeds which are high compared with previous Diesel practice.

About five years ago, when they began work on the *R-100* and *R-101*, the British undertook the development of a compression-ignition engine for airships. The Beardmore Diesel was the result. These engines were used on the *R-101*, and from the limited information which has been published on the subject, they performed very satisfactorily during the extremely short life of that vessel. This engine, however, is excessively heavy, and is still to be considered as in the experimental and development stage.

The British have in recent years stressed the advantages of heavy-oil compression-ignition engines from the fire-hazard point of view. They deserve great credit for their courage and perseverance in attacking this problem, and carrying forward the task of engine development to the point of obtaining an engine which they have used in one ship, however imperfect this engine may now be. It is to be noted furthermore that, from all evidence available, the engines of the *R-101* functioned perfectly on her fatal voyage and were in no wise a contributory cause to the wreck and burning of that vessel.

Visualizing the bigger and better airships of the future, it becomes at once apparent that we must have power plants of higher horsepower ratings for them. With ships of the present displacements, we could well use 1000-hp. engines were they available. For larger vessels, such engines, and ones of higher unit-horsepower ratings, will be essential. Six to eight engines can economically be utilized in one ship.

The unavoidable slowness of engine evolution will, for some years to come, constitute an effective obstacle to the further increase in size, and therefore efficiency, of airships, which otherwise could expand rapidly in displacement. It is idle to talk of 8- to 10-million cubic-foot vessels until suitable power plants for such ships are in sight.

Power Transmissions

As set forth earlier, the use of helium and of deep-section main frames made it possible and desirable to place the engines in engine rooms within the hull of the ship. Therefore the problem was presented of connecting the engine and the propeller with a transmission system which would necessarily be much more extensive than the transmissions needed in outboard power cars. The solution which was adopted was to use bevel gearing between the propeller and the long athwartships driveshaft coming out through the skin of the ship from the engine. The engine is of course mounted with its crankshaft athwartships, and coupled to the transmission shafting through a flexible coupling. The portion of the transmission system in the engine room includes a friction brake, a jaw clutch, a pulley for belt drive for the exhaust-manifold cooling blower, and the ballast-water-pump drive. The outboard bevel-gear housing is held rigidly by struts anchored to the ship's hull.

Two very important possibilities were immediately apparent from the above-mentioned arrangement. First, the bevel gear could just as easily be made a bevel reduction gear, stepping the full engine speed of 1600 r.p.m. down to 925 r.p.m. at the propeller, and thereby increasing the propulsive efficiency of the propellers. Second, the propeller could be "tilted" down through 90 deg. in the vertical fore-and-aft plane, thus bringing it into position for vertical thrust instead of horizontal thrust.

The tilting of the propeller is accomplished by means of a worm gear operated from the engine room. The outer tiltable section of the gear housing is locked in either position, for horizontal or vertical thrust, by a jaw-clutch locking device. This tilting feature will often be very valuable to the ship in landing, taking off, and maneuvering near the surface.

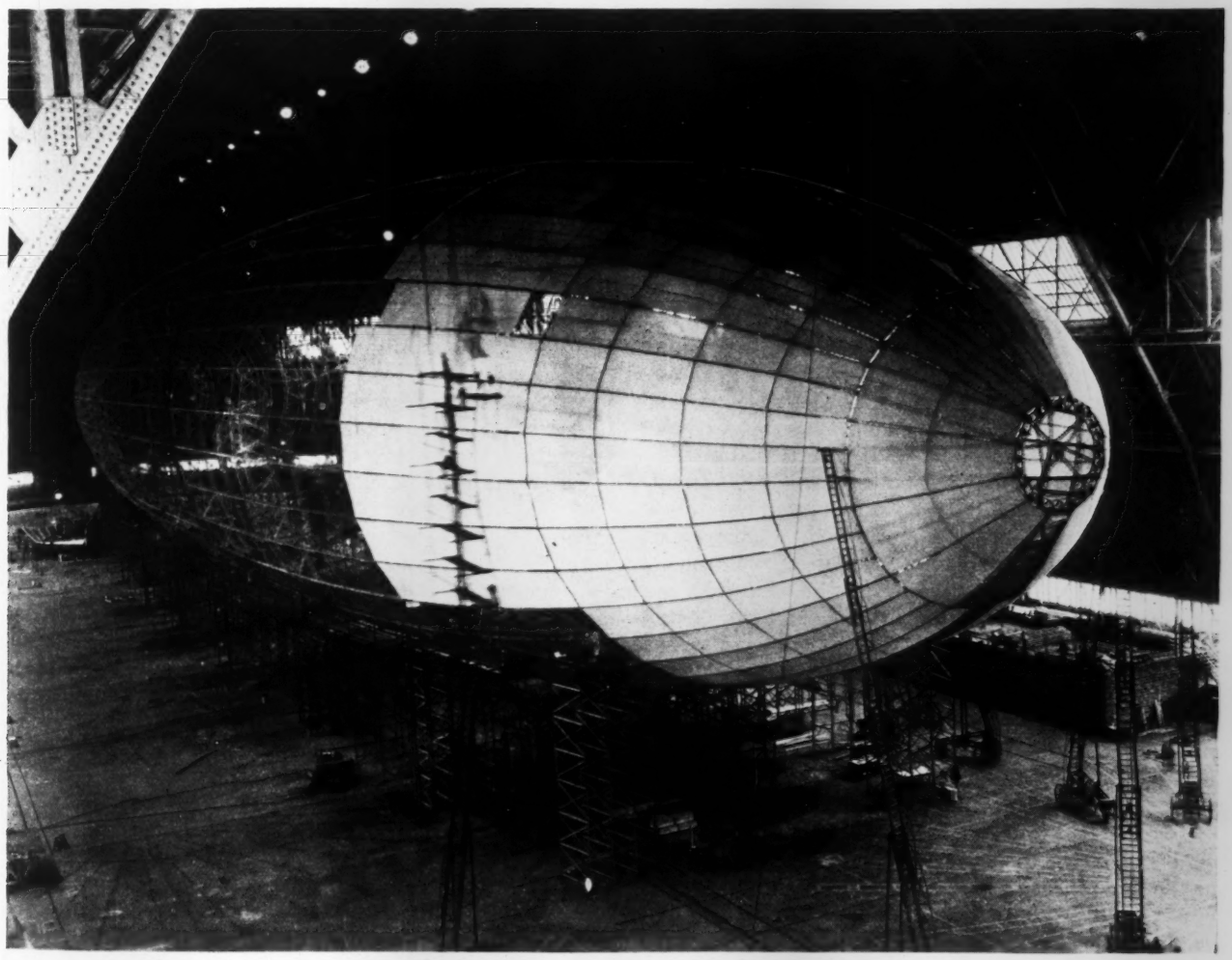
In the *Akron*, the propellers are wooden, two-bladed, over 16½ ft. in diameter, and will be "tractors" for normal "ahead" thrust; they will tilt down, therefore pulling the ship down when the engines are going in the ahead direction, and shoving her up when the engines run "astern."

Fuels and Ballast-Recovery Equipment

Gasoline has the advantages of cheapness and ready availability, but it also has two disadvantages: first, high inflammability and explosiveness; and second, weight, which means increasing lightness of the ship as the fuel is burned. To avoid the fire hazard of gasoline, the British used heavy-oil fuel in the Beardmore compression-ignition engines of the *R-101*. Paradoxically, this ship was destroyed by fire after her wreck at Beauvais in October, 1930; the fire, however, was a hydrogen fire, a lifting-gas and not a fuel fire.

To offset the second disadvantage of gasoline, that of its weight, two solutions have been demonstrated on full scale: namely, water-recovery equipment and gaseous fuels. Our Navy has developed water-recovery equipment in the *Shenandoah* and *Los Angeles*, and such equipment will be used in the *Akron*. It consists essentially of an air condenser through which the engine

exhaust is passed; the exhaust gases are cooled and the contained water vapor condensed into water particles which are collected in a separator and drained off into the ballast system. Approximately 145 lb. of water vapor exists in the exhaust gases resulting from the combustion of 100 lb. of gasoline fuel in an airship engine. With service-type water-recovery equipment, 85 to 110 lb. of this water per 100 lb. of gasoline burned



SHOWING THE BOW OF THE "AKRON"

are usually recoverable. Thus the ship can cruise for long periods with little or no increase in lightness due to use of fuel—often an increase in heaviness can be realized. A further operational advantage lies in the ability of a ship to take off with a very small quantity of water ballast on board, knowing that long before arriving at her destination she will have converted an amount of gasoline into water which will be ample for ballasting purposes. The *Los Angeles* has operated for a continuous period of a year without valving any helium whatever.

Dr. Eckener has demonstrated the use of gaseous fuels very fully and successfully in the *Graf Zeppelin*. He has used several fuels, all hydrocarbon gases, or such gases mixed with hydrogen. All such fuels used by the *Graf Zeppelin* have been very slightly heavier than air, i.e., specific gravities of approximately 1.05 relative to air. Consequently the lift of the ship changes but slightly because of the burning of fuel, even on long voyages. Gaseous fuel has a further advantage in that considerably higher compression ratios can be used in the engines than with gasoline, without detonation or preignition. Therefore increased horsepower output can be obtained, specific fuel economy in pounds per horsepower-hour is bettered, and the engines seem to run smoother than with liquid fuel. The performance of an airship is considerably bettered through the use of gaseous as compared with gasoline fuel for still another reason. The volume in the ship occupied by the gaseous fuel is considerably less than the volume of lifting gas which would have been required to lift a corresponding quantity of gasoline. Therefore a greater quantity of heat units can be carried under given conditions when the fuel is in the gaseous form than when in the form of liquid gasoline. Of course a number of structural and other features and weights are

changed in a gaseous-fuel ship, and while the algebraic sum of these weight changes is probably in favor of gasoline, it does not offset the greatly increased performance otherwise resulting from the use of gaseous fuel.

The matter of whether gaseous fuel is more or less of a fire hazard than gasoline is very involved; a number of factors bear on it, and the answers may be different for different lifting gases and for different types of service for which vessels are built. However, our Navy takes the position that for helium-filled Naval airships, gaseous fuel would involve an unwarranted loss of safety from fire, and that its use is therefore not justified in that type of vessel, despite its indicated performance advantages.

Electrical Systems and Radio

The *Akron* will have a much more comprehensive electrical layout than any previous or contemporary ship. There will be two main gasoline-engine-driven generators, each capable of delivering 8 kw. of power into the ship's mains, 110 volts d.c., for an indefinite period, with overload capacities for short periods considerably in excess of this figure. The two machines can be paralleled up for peak conditions, in this way making a normal full-load power of 16 kw. available. The 110-volt mains will supply general ship's lighting circuits, fuel-pump motors, ventilation-fan motors, radio, miscellaneous needs in the airplane hangar, some auxiliary cooking utensils and water heaters, etc. There will be in addition several 24-volt circuits in the ship for such purposes as instruments and instrument lighting, telephone system, etc. These 24-volt circuits will be supplied by a motor-generator driven from the 110-volt mains. There will be a large-capacity storage battery floating on the 24-volt system, ready to take up the work of power supply to this system in the remote contingency of a failure of the ship's main 110-volt power sources. The *Akron* will have by far the most powerful and, we hope, the most efficient radio equipment so far installed on any airship. Both high-frequency and intermediate-frequency transmitters will be provided, while receiving and radio-compass equipment will span all used frequencies.

Crew Quarters, Passenger Accommodations, and Naval Features

On our two new airship cruisers there will be very ample provision for the officers and men of the crew as to living quarters. In a commercial ship of this size, very adequate passenger accommodations would, of course, be built in the ship—staterooms, saloon, added washroom, pantry, and galley facilities, promenades, etc. In a naval vessel, the weight which is saved by omitting these passenger accommodations is utilized in guns, ammunition, bombs, observation basket, fire-control systems, and the other necessities of a naval vessel.

One of the most important innovations in the *Akron* will be her facilities for carrying and "mothering" airplanes. She will have five of these craft, housed in a very adequate hangar in the bottom of the vessel somewhat forward of amidships.

Naval and Commercial Roles of Airships

Naval Rôle. As a naval vessel, the airship is primarily a scout cruiser. Under many sets of circumstances the airship scout cruiser is considerably more efficient and valuable than a surface cruiser. The airship has over twice the full speed of the surface cruiser, and under proper conditions can partake of the submarine's "long suit," invisibility, by taking cover in clouds. These two advantages are of the highest importance in comparing the airship scouting vessel with the surface scouting vessel. However, it must not be assumed from this that the airship replaces the surface scout in naval strategy; such is far from the case.

In general each naval type of vessel has secondary functions; those of the airship are: convoy escort, commerce control and raiding, bombardment of enemy coasts, maintenance of own lines of communication, raiding or interrupting enemies' communications, dispatch, and rapid transport.

There is a widespread popular misconception to the effect that airships are very fragile and vulnerable, especially to airplane attack. However, the facts are that naval airships, utilized in their proper rôles, and handled by adequately experienced crews, are not at all fragile, and are not relatively more vulnerable than are other auxiliary naval types.

Commercial Rôle. Merchant airships will largely parallel surface ocean shipping routes as to countries served, but not as to actual tracks over the oceans. The great speed and endurance of the airship enables it to detour around foul weather, to seek fair winds and shun head winds, while the slow surface craft is bound to certain lanes and "must take what comes" in the way of weather.

The airship can offer a saving in time of two days for the North Atlantic crossing as compared with the fastest surface liners. On other oceans considerably greater relative savings in time can be shown, as compared with the best present surface transportation. It may be said that the airship will reduce the dimensions of the oceans to half or less of their present spans, just as the airplane is shriveling the continents.

The importance to all kinds of commercial express traffic of the high speed, safety, and reliability offered by the airship cannot be overestimated. These advantages would seem to be particularly important in so far as the mails are concerned. While airships, for a long time to come, will not be able to provide passengers the elaborate luxuries of our present modern transatlantic floating hotels, nevertheless, all necessary comforts and some luxuries will be arranged. The airship is by far the most comfortable vehicle in which to travel, except possibly the surface liner, and in one important respect the latter is outclassed by the former: seasickness is unknown in airships, except in the cases of a very few supersensitive persons.

An International System of Fits

Proposal Developed Under the Procedure of the International Standards Association[1]

By JOHN GAILLARD,[2] NEW YORK, N. Y.

WORK to develop an internationally uniform standard system of fits has been done during the last few years by a technical committee organized under the procedure of the International Standards Association (I.S.A.).

In an article entitled "International Unification of Standard Fits," published in the October, 1930, issue of MECHANICAL ENGINEERING, this development was briefly described. The I.S.A. proposal under consideration at that time was put into final shape for submission to the 18 member-bodies of the I.S.A.—including the American Standards Association (A.S.A.)—in November, 1930. Its essential features are presented in the following report in the same form as submitted by the A.S.A. to its Sectional Committee B4 on Allowances and Tolerances for Cylindrical Parts, and Limit Gages, for its information. This committee, organized in 1920 under A.S.A. procedure by the A.S.M.E. as sponsor body and reorganized in the fall of 1930 to review, and if necessary revise, the present American standard on fits,[3] has declared its willingness to cooperate as far as possible in the international standardization activities concerning this project.

The following report deals with the basic features of the proposed international system only. A questionnaire relating to these features is given at the end of the report for consideration by Sectional Committee B4.

Reports on details of the international proposal, such as tables of numerical values of allowances and tolerances, will be submitted to Sectional Committee B4 if and when it appears possible for American industry to come to an agreement with the other countries on the basic principles.

1[4]—Reference Temperature

The I.S.A. proposal recommends that the reference temperature for limit gages and other measuring tools and equipment be 68 deg. fahr. (20 deg. cent.).

In 1928, sixteen out of eighteen countries that answered the questionnaire of the international secretariat, were found to have adopted the reference temperature of 68 deg. fahr. In France the temperature of 32 deg. fahr. has been generally used so far. However, the French delegates on the I.S.A. subcommittee expressed their willingness to change to 68 deg. fahr. if this reference temperature becomes internationally adopted.

The American Tentative Standard B4a-1925 also specifies the temperature of 68 deg. fahr., which appears to have been generally adopted in American industry.

2—Range of Diameters Covered

The I.S.A. proposal covers a range of diameters up to 180 mm., or about 7 in., inclusive. Numerical data of allowances and tolerances were developed for this range first, as it comprises the diameters most frequently used.

The range of diameters from above 180 mm. up to 500 or 600 mm., that is, from about 7 in. to about 20 or 24 in., will be considered later. The national bodies are invited to express their opinion as to whether diameters larger than 7 in. should be dealt with, and if so, whether the range of diameters covered should be extended to 20 or to 24 in.

3—Subdivision of Range of Diameters

The I.S.A. proposal recommends the following subdivision of the range of diameters up to 180 mm., inclusive:

Millimeters: 1 3 6 10 18 30 50 80 120 180

NOTE: The subranges extend from above each figure to the next higher figure, inclusive. For example, the range 30–50 mm. covers diameters from above 30 to 50 mm., inclusive.

This subdivision was chosen on the basis of the subdivisions that had already been adopted in the national standards of eleven countries.

The inch values very closely approximating the above metric values are:

Inches: 0.04 1/8 1/4 13/32 23/32
1 3/16 2 3 1/8 4 3/4 7 1/8

The following somewhat more rounded inch values would probably serve equally well as approximate conversion figures:

Inches: 0.04 1/8 1/4 3/8 11/16
1 1/4 2 3 1/4 4 3/4 7

In fact, the essential requirement in establishing equivalent inch and metric series of this kind is that any specific diameter, whether in inches or millimeters, that is commonly used in practice shall lie within the same subrange in either system. This will be explained here by a concrete sample.

A metric shaft with a diameter of 30 mm. belongs

[1] Report prepared for the information of the American Standard Association's Sectional Committee on "Allowances and Tolerances for Cylindrical Parts, and Limit Gages" (B4).

[2] Mechanical Engineer, American Standards Association.

[3] American Tentative Standard B4a-1925 on Tolerances, Allowances, and Gages for Metal Fits.

[4] Numbers in headings refer to similarly numbered paragraphs in the questionnaire reproduced at the end of the Report.

to the subrange from 18 to 30 mm., inclusive (see Note above). The next larger diameter adopted as a standard diameter in several metric countries is 32 mm. This shaft lies within the subrange from 30 to 50 mm.

As a boundary between the two subranges—18 to 30 mm. and 30 to 50 mm.—the value $1^1/_4$ in., or about 31.75 mm., appears to be a suitable practical equivalent of the metric figure 30 mm. The question now arises if it actually may safely be used as such a boundary, or whether difficulties may occur through the values 30 mm. and $1^1/_4$ in. falling within non-corresponding subranges. Evidently, if no metric diameter between 30 and 32 mm. is used in actual practice, there is no objection to the use of the value $1^1/_4$ in. instead of the closer approximation $1^3/_{16}$ in. This consideration led to the two series of conversion figures in inches given above.

In determining the equivalent inch and metric subranges, the foregoing question must probably be given careful study. However, this is a detail, the essential questions being whether the fewer number of subranges into which the total range up to 7 in. is divided, and these subranges themselves, will be acceptable to American industry.

In the American Tentative Standard B4a-1925, the range of diameters up to about 7 in. is divided into more than twenty subranges instead of nine as suggested in the I.S.A. proposal. Objections to these small subdivisions have been raised by firms otherwise applying the American Tentative Standard B4a to their satisfaction. In fact, some firms report that in their practice they have reduced the number of subranges by combining adjacent subranges.

4—Relation Between Tolerance or Allowance, and Nominal Diameter

In developing the I.S.A. proposal, no effort has been made to establish basic formulas expressing the relationship between nominal diameters on the one hand, and allowances or tolerances on the other. The I.S.A. subcommittee preferred to base the proposed allowances and tolerances on the numerical values that have been laid down in the existing national systems.

This decision was based on the consideration that the formulas used in building up the existing national systems have been developed on the basis of practical data, and do not represent mathematical or physical laws. The formulas used in the several countries vary, and there seemed to be no good reason for searching for a method of comparing them instead of basing directly on the practical data. The soundness of this procedure seemed the more evident, as the numerical values of the allowances and tolerances adopted for similar fits in the several national systems are frequently almost, and sometimes entirely, the same, although they were developed on the bases of different formulas.

The American Tentative Standard B4a-1925 is one of those that have been developed on the bases of formulas for Recommended Allowances and Tolerances, derived from practical data. These formulas are tabulated on page 24 of the standard, which says, on page 23:

> In the foregoing allowances and tolerances, the best practice available was considered, and where differences occurred, a compromise was attempted.

5—Basic Hole and Basic Shaft System

The I.S.A. proposal recommends that the international system should comprise fits in the Basic Shaft System as well as in the Basic Hole System.

This recommendation is based on the consideration that both systems are needed by a national industry considered as a whole, and also on the fact that 13 countries had decided—as shown by the canvass made in 1928—to include both systems in their national standards.

The American Tentative Standard B4a-1925 gives fits in the Basic Hole System exclusively, but the desirability of having fits in the Basic Shaft System added to the standard has been brought to the attention of the A.S.A. office on several occasions, one of these being the reorganization meeting of Sectional Committee B4.

6—Character of the Tolerances

The I.S.A. proposal recommends the adoption of the nominal size of the mating parts as the zero or reference line, the holes in the Basic Hole System to have plus tolerances, and the shafts in the Basic Shaft System minus tolerances, on the nominal size. In a similar way, the tolerances on all other holes and shafts are also measured in one direction from their basic size only. In other words, the adoption of *unilateral* tolerances is recommended.

Two technical advantages are mentioned in the I.S.A. proposal in support of this recommendation. One advantage is that the "Go" gages are the same for all parts with the same maximum metal limit, whatever their minimum metal limit may be. For example, in the Basic Hole System the same "Go" plug gage can be used for all basic holes, independently of the numerical value of their tolerance. The other advantage mentioned is that a change in unilateral tolerances requires a shift in the "Not Go" limit exclusively, whereas a change in bilateral tolerances requires a shift of both limits, "Go" and "Not Go."

7—Set-Up of Proposed I.S.A. System

Before discussing the manner in which the set-up of the proposed international system was developed, it will be necessary to explain the distinction made in several Continental standards between the "class" and the "grade" of a fit. The I.S.A. proposal being intended as a compromise between the existing national standards, this distinction was kept in mind by the I.S.A. subcommittee in working out its proposal, although later on the distinction between "class"

and "grade" of fit was dropped, as will be seen further on.

According to the Continental definition, the "class" of a fit depends on the *allowance*, that is, on the minimum looseness of a clearance fit, or the maximum tightness of a transition or interference fit. The "grade" of a fit, however, depends on its maximum permissible *variation* in looseness or tightness. Therefore, if two fits A and B have the same minimum clearance, but B has a larger maximum clearance than A, then fit A is of a higher "grade" than fit B.

The explicit distinction between "class" and "grade" of fit is unusual in American practice. The American Tentative Standard B4a-1925 does not make this distinction, but specifies eight fits completely defined as to the limits of hole and shaft, each fit being designated by a name and a "class" number. The term "class" is not defined in the American standard, but has simply been adopted to distinguish one fit from another. Also, the allowances of the eight fits all being different, there is no particular need, in so far as the American standard is concerned, of distinguishing between different "grades" of fits, nor between the concepts "class" and "grade of fit" as defined by the Continentals.

It is true, however, that the American standard practically permits the cross-mating of holes and shafts and consequently the establishment of fits with the same allowance, but different variation in looseness or tightness—that is, fits of the same "class," but different "grades." For example, when a Class 3 shaft is mated with a Class 4 hole, the fit thus obtained is of a higher "grade" than when that shaft is mated with a Class 3 hole, while the allowance (minimum clearance), and therefore the "class" of the fits (in the European sense of the word), is the same for both.

While developing its proposal, the I.S.A. subcommittee conserved the subdivision of the fits into grades, each grade comprising a certain number of classes of fits. As will be described later in more detail, four different grades of fits were adopted, the total tolerance on the mating parts being smallest for the finest grade, and so on. It was thus possible to establish a compromise between the existing national systems in which the fits are also subdivided into grades, as already stated.

Once the proposed I.S.A. system had been worked out, the I.S.A. subcommittee decided to abandon the idea of subdividing the fits into grades and classes. Instead, it preferred to group together the standard holes and shafts on the basis of their respective tolerances. Thus, several groups of standard holes and shafts were established, each group comprising holes or shafts with the same tolerance. (To be exact, slight deviations are sometimes found in the tolerances on parts of the same grade. These deviations are understood to be due to the necessity of compromising between existing national systems and not to have any essential significance.)

The foregoing distinction between "class" and "grade" of fit has been conserved in the following discussion, in order better to explain how the I.S.A. proposal resulted from consideration of four major questions:

a How many grades of fits should be adopted?
b What classes of fits should be comprised in each grade?
c What mutual relationship should the different grades have?
d How should the total tolerance be distributed between the hole and the shaft giving together a fit of a certain standard grade?

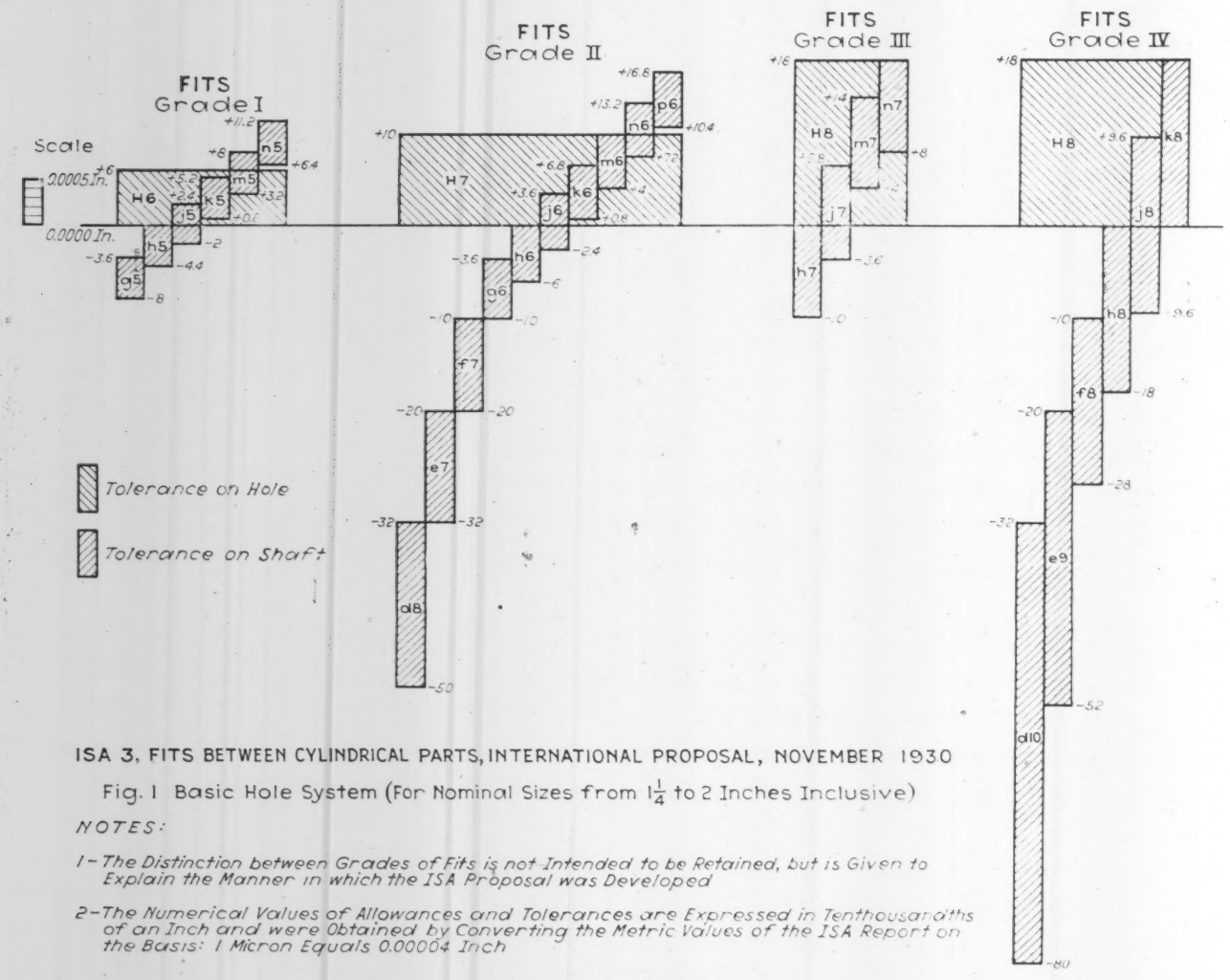
Before dealing with these questions, it seems well to visualize the essential set-up of the I.S.A. system by a concrete example in reference to Figs. 1 to 4, inclusive. The figures represent the tolerances on standard holes and shafts recommended in the I.S.A. proposal for nominal sizes of from 30 to 50 mm., inclusive, or in inch values, from about $1^1/_4$ to 2 in., inclusive. The range from $1^1/_4$ to 2 in. has been chosen because it covers a series of diameters that are widely used in different branches of industry. The reference line in Figs. 1 to 4 has been assumed to represent the nominal size of $1^1/_2$ in. The cross-hatched bars represent the tolerances on holes and shafts, the direction of the cross-hatching indicating whether the tolerance applies to a hole or to a shaft.

Figs. 1 and 2 represent fits between combinations of the standard holes and shafts. These fits are of different "classes" and "grades," to use the Continental terminology explained above. Figs. 3 and 4, on the contrary, show the standard shafts and holes independently, that is, without reference to the fits which they give when mated.

Fig. 1 represents a series of fits in the Basic Hole System. The fits are subdivided into four groups, each group comprising fits belonging to the same grade of fit. The grades of fits, I, II, III, and IV, are thus obtained. The tolerance on the basic hole is constant for each grade of fit. The hole tolerances for Grades I, II, and III are different, but the hole tolerance on the Grade IV hole is the same as that on the Grade III hole. Therefore, three different basic holes cover the requirements of the four grades of fits in the Basic Hole System.

Fig. 2 represents a series of fits in the Basic Shaft System. These are also divided into four grades of fits, the shaft tolerance being constant here for each grade. Each basic shaft has a different tolerance, the four grades of fits in the Basic Shaft System consequently being covered by four shaft tolerances.

Fig. 3 represents all of the standard shafts that appear in Fig. 1. They are arranged here in "grade" groups according to their tolerance. In addition to these shafts, nine standard shafts with large tolerances appear in Fig. 3. The latter are not meant to be used in specific hole-shaft combinations as shown in Fig. 1, but have been added to take care of special require-



ISA 3, FITS BETWEEN CYLINDRICAL PARTS, INTERNATIONAL PROPOSAL, NOVEMBER 1930

Fig. 1 Basic Hole System (For Nominal Sizes from $1\frac{1}{4}$ to 2 Inches Inclusive)

NOTES:

1 – The Distinction between Grades of Fits is not Intended to be Retained, but is Given to Explain the Manner in which the ISA Proposal was Developed

2 – The Numerical Values of Allowances and Tolerances are Expressed in Tenthousandths of an Inch and were Obtained by Converting the Metric Values of the ISA Report on the Basis: 1 Micron Equals 0.00004 Inch

FIG. 1 BASIC HOLE SYSTEM

ments. The tolerance on a Grade 10 or Grade 11 shaft may be suitable also in cases where the shaft is not to be mated with a hole, that is, where no establishment of a specific fit is involved.

The shafts in each group represented in Fig. 3 have the same tolerance and are said to be of the same "grade." It should be noted that the term "grade" applies to the magnitude of the tolerance only, and not to the surface finish of the part.

Altogether, seven different grades of shafts are given in Fig. 3, designated as Grades 5 to 11, inclusive. The finest grade of shaft has been designated as Grade 5—and not as Grade 1—in order to reserve still finer standard grades—with closer tolerances—for limit gages and for possible future refinement of the entire system.

Fig. 4 shows the standard holes given in Fig. 2, also grouped into grades according to their respective tolerances. There are only six different grades of holes, as against seven different grades of shafts, there being no Grade 5 holes (see Fig. 3). Generally speaking, the fits shown in Figs. 1 and 2 occur between a hole of a certain grade and a shaft of the next finer grade.

The tolerances on holes and shafts designated by the same grade number are equal; e.g., the $1^1/_2$-in., Grade 6, shaft h 6 in Fig. 3, and the $1^1/_2$-in., Grade 6, hole H 6 in Fig. 4, both have a tolerance of 0.0006 in.

The four questions listed above which were given consideration by the I.S.A. subcommittee, will now be dealt with.

(*a*) *Number of Different Grades of Fits.* The adoption of the grades of fits I to IV must be considered as a compromise between the several national systems, which in general comprise three to five grades of fits.

The starting point in setting up the I.S.A. proposal was the series of Grade II fits, these being the ones most commonly used by industry in general. Also, there appeared to exist a considerable degree of similarity between this grade of fits in the several national systems.

Subsequently the finer grade of fits I and the coarser grades of fits III and IV were added. Grade I is intended, for example, for precision machine tools,

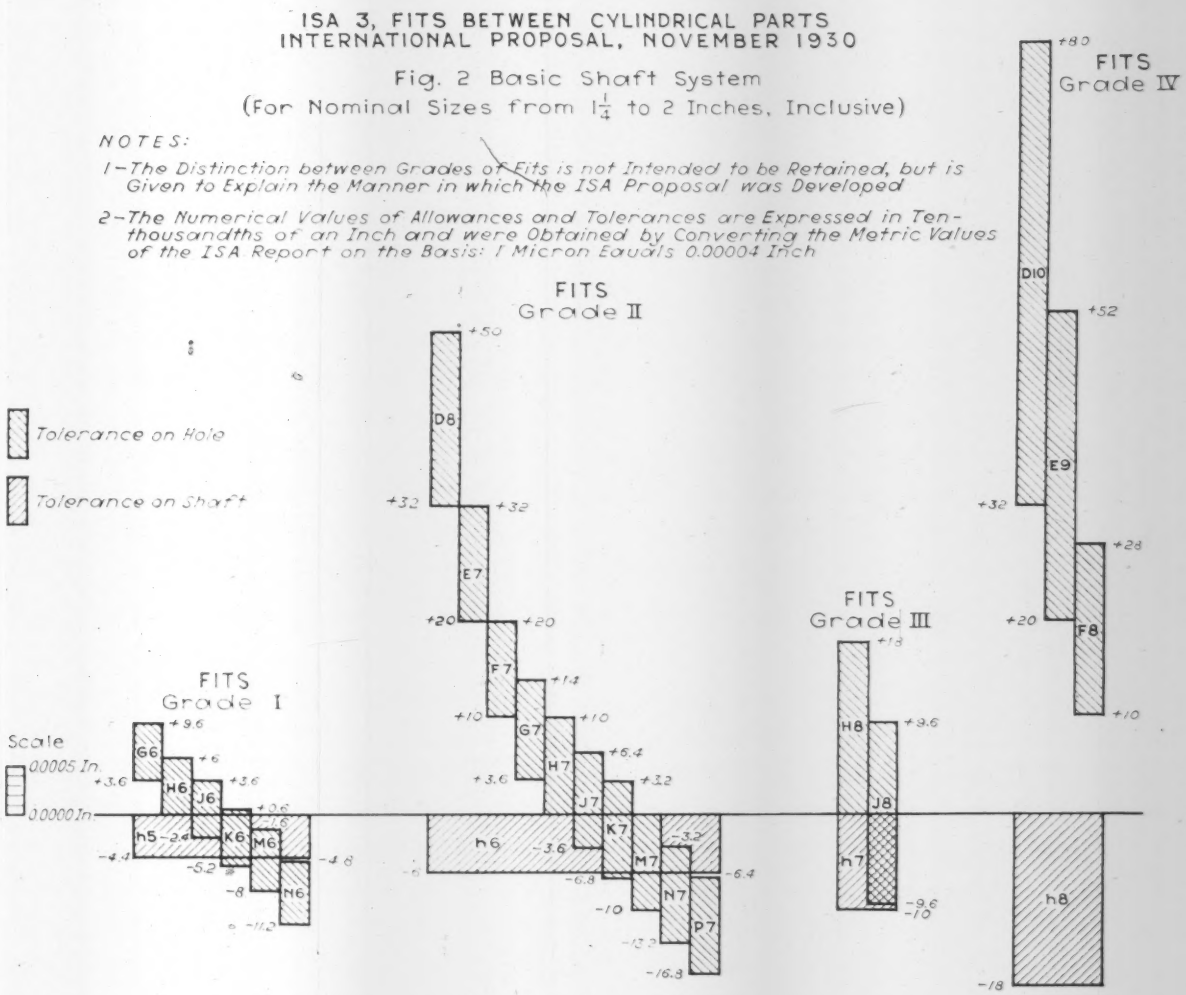


FIG. 2 BASIC SHAFT SYSTEM

while Grades III and IV will serve, for example, for certain parts of agricultural machinery and railway cars. Incidentally, Grade III is equivalent to the third grade in the Swedish and Czech standards, while Grade IV is equivalent to the German third grade. This clearly shows the changes from the existing systems made in the I.S.A. proposal for the sake of compromise.

(*b*) *Classes of Fits in Each Grade.* The main question to be discussed in this respect was whether Grade III fits should or should not comprise transition fits. Transition fits are those which may have a clearance or an interference, depending on whether a hole that is on the large side happens to be mated with a shaft that is on the small side, or conversely. The French, German, and Swiss delegates were of the opinion that transition fits should not have tolerances larger than those of Grade II fits. Else the chance of obtaining a fit of the desired character would be too small, in their opinion. The Czech delegates, on the other hand, held that transition fits could suitably be established not only in Grade II, but also in Grade III.

It was finally decided that Grade III would include transition fits, but the I.S.A. proposal emphasizes the fact that such fits naturally give a lower chance of "hitting the target" than those of Grade II. The former are held to be suitable, however, for less exacting work and for shops that are not so well equipped as to be able to maintain the tolerances required for Grade II fits.

(*c*) *Relationship Between Grades of Fits.* Table 1 shows the tolerances on basic holes and shafts used for the different grades of fits, for parts with a nominal size from $1^1/_4$ in. to 2 in., inclusive. It also shows the total tolerances, and the ratios between the latter. The total tolerance on parts giving Grade II fits—the most commonly used grade—has been adopted

TABLE 1 TOLERANCES ON PARTS WITH A NOMINAL SIZE FROM $1^1/_4$ IN. TO 2 IN. FOR DIFFERENT GRADES OF FITS

(Values in ten-thousandths of an inch)

	Grade of fit			
	I	II	III	IV
Hole tolerance (H)	6	10	18	18
Shaft tolerance (S)	4.4	6	10	18
Total tolerance (T)	10.4	16	28	36
Ratio between each value T and the value T of Grade II	0.65	1	1.75	2.25

as the value 1 (see last line of Table 1), and the total tolerances of the three other grades have been expressed accordingly.

In connection with the foregoing, it may be interesting to mention the machine finishes recommended by way of example in the I.S.A. proposal for the different grades of fits. These are listed in Table 2.

(*d*) *Ratio Between Hole and Shaft Tolerance.* The large majority of fits represented in Figs. 1 and 2 occur

TABLE 2 MACHINE FINISHES FOR DIFFERENT GRADES OF FITS

	Grade of fit				
	I	II	III	IV	Coarser work
Hole	very high-grade reaming, grinding, or smooth-tooth broaching	high-grade reaming	reaming	reaming or boring	drilling
Shaft	very high-grade grinding	grinding	very careful turning	careful turning or precision drawing	plain turning or drawing

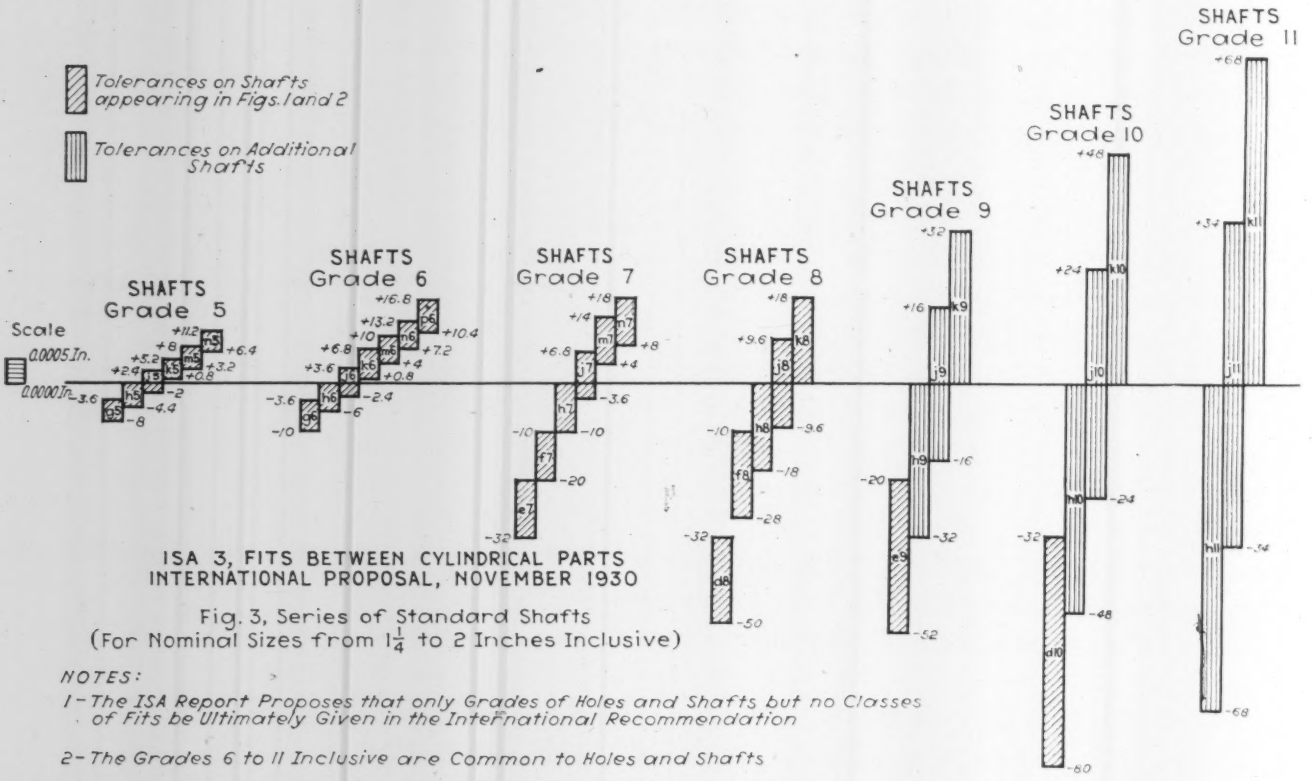


Fig. 3, Series of Standard Shafts
(For Nominal Sizes from $1\frac{1}{4}$ to 2 Inches Inclusive)

NOTES:
1 - The ISA Report Proposes that only Grades of Holes and Shafts but no Classes of Fits be Ultimately Given in the International Recommendation
2 - The Grades 6 to 11 Inclusive are Common to Holes and Shafts

FIG. 3 SERIES OF STANDARD SHAFTS

between a hole and a shaft having different tolerances, the shaft tolerance being the larger one. Only in a few cases are the tolerances on the mating parts equal, such as those of the fits of Grade IV, Basic Hole System, Fig. 1; and of one of the Grade IV fits, Basic Shaft System, Fig. 2.

The larger tolerance on the hole is based on adoption of the fact that it is more difficult in manufacturing practice to keep a hole within a given tolerance than a shaft. In this connection the I.S.A. proposal contains the following statement:

> While nowadays shafts frequently are ground, the mating holes usually are still produced by reaming, an operation requiring a larger tolerance. However, it is sometimes held that even in cases where the holes are ground, a larger tolerance is required than for grinding shafts. This opinion is based on the fact that in producing holes, a deviation from the true cylindrical shape is more difficult to avoid.

In the Grade II fits—the most important group—the hole tolerance amounts on the average to somewhat over 60 per cent of the total tolerance on hole and shaft. To be exact, the percentage varies from 62 to 65 for the different subranges of diameters between about 0.04 in. and 7 in. For the subrange from $1\frac{1}{4}$ in. to 2 in., represented in Figs. 1 to 4, the percentage is 62.

8–9—Designation of Fits by Symbols

The I.S.A. proposal recommends that the grades of holes and shafts—and therefore their tolerances—be designated by numerals, and the position of the tolerance relative to the reference line—and therefore the allowances—by a letter. Capitals are used for the holes, and lower-case letters for the shafts. The basic holes are thus designated by the symbols, H 6, H 7, etc., and the basic shafts by the symbols h 5, h 6, etc. For further symbols, see Figs. 1 to 4, inclusive.

A fit between two mating parts is designated by the symbol for the hole, followed by the symbol for the mating shaft. The two symbols may be hyphenated or separated by a slanting line, for example, H 7-d 8, or H 7/d 8.

Incidentally, standardization of the method of indicating fits on drawings will not be dealt with by the I.S.A. Technical Committee No. 3 on Fits, but by its Technical Committee No. 10 on Drawings.

10—Working and Inspection Gages

The I.S.A. proposal recommends that the values adopted for the manufacturing limits of the work be considered as the nominal sizes of the working gages, that is, of the gages used by the machine operator in the shop.

In order to explain the adoption of this seemingly obvious principle, it should be noted that some of the existing national systems make distinction between three kinds of gages: working gages, shop inspection gages, and purchaser's inspection gages. Different sets of limits are given for each kind of gages in the systems concerned. The I.S.A. subcommittee decided that the problem of inspection gages—both shop and purchaser's—would be dealt with later.

11—Manufacturing Limits and Permissible Wear of Gages

In the ideal case, the actual sizes of the "Go" and the "Not Go" gages would exactly represent the limits of the work. However, the gages themselves being manufactured products, they inevitably vary more or less from their nominal sizes. For example, a "Go" plug gage for a hole with a low limit of 1.0000 in. may be found actually to measure 1.0001 in. Also gages are subject to wear through use—especially "Go" gages.

Besides specifying limits for the work, a standard on fits must therefore also lay down rules governing the permissible variation of limit gages from their nominal sizes. This regards both the unavoidable inaccuracy in the manufacture of the gages, and their change in size through wear.

In principle, two different standpoints may be taken with regard to this question. One standpoint is a very strict one. Its advocates, holding that the limits of the work are set with the definite purpose of keeping the work absolutely within these limits, object to any variation in gage size—whatever its cause may be—that would result in the acceptance of work that is outside its own limits, or, conversely, in the rejection of work that is duly within its own limits. According to this view, all variations of a gage from its nominal size must therefore lie within the tolerance on the work.

The other, more liberal, standpoint is that the actual size of a limit gage is permitted occasionally to lie slightly outside the tolerance on the work. For example, considering again the above example of the "Go" plus gage for a hole with a low limit of 1.0000 in., it would be permissible for such gage to have a size of 0.9999 in. as a result of wear. The gage would then accept holes smaller than 1.0000 in., and although such holes are, strictly speaking, too small, those advocating the more liberal standpoint referred to hold that no great harm can be done by the acceptance of such holes. This viewpoint is based on the ground that the holes in question are liable to cause trouble only when assembled to shafts which are also somewhat outside their own limits, but on the large side. Three

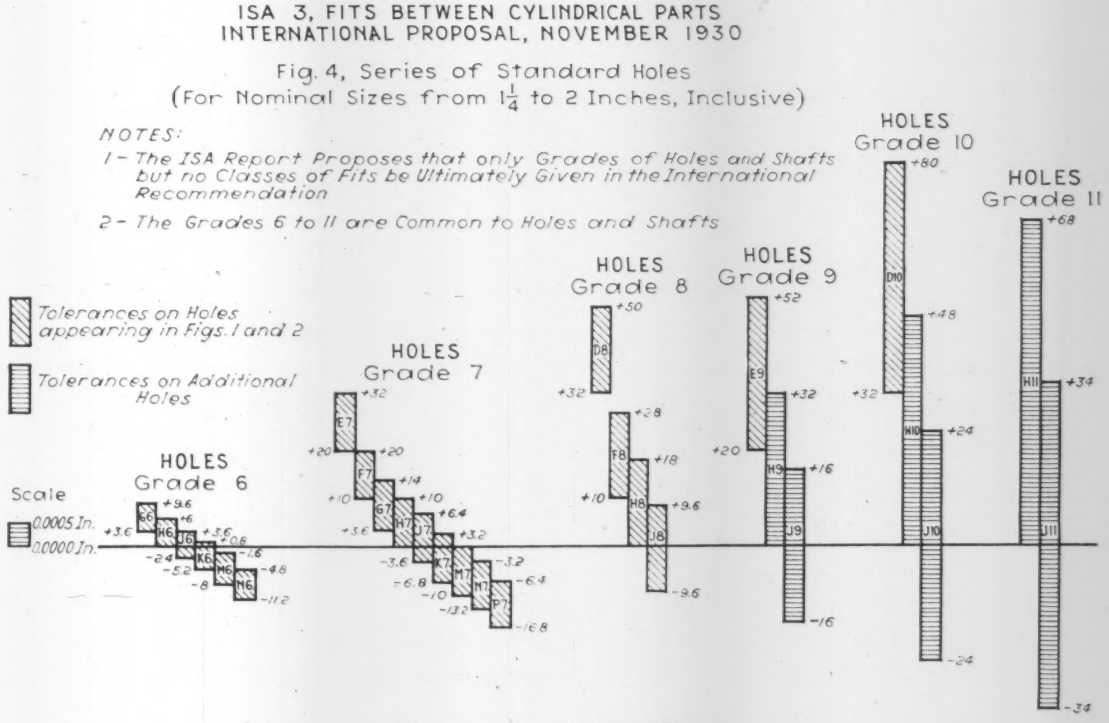

ISA 3, FITS BETWEEN CYLINDRICAL PARTS
INTERNATIONAL PROPOSAL, NOVEMBER 1930
Fig. 4, Series of Standard Holes
(For Nominal Sizes from 1 1/4 to 2 Inches, Inclusive)
NOTES:
1 - The ISA Report Proposes that only Grades of Holes and Shafts but no Classes of Fits be Ultimately Given in the International Recommendation
2 - The Grades 6 to 11 are Common to Holes and Shafts
Tolerances on Holes appearing in Figs. 1 and 2
Tolerances on Additional Holes
Scale
0.0005 In.
0.0000 In.
HOLES Grade 6
HOLES Grade 7
HOLES Grade 8
HOLES Grade 9
HOLES Grade 10
HOLES Grade 11

FIG. 4 SERIES OF STANDARD HOLES

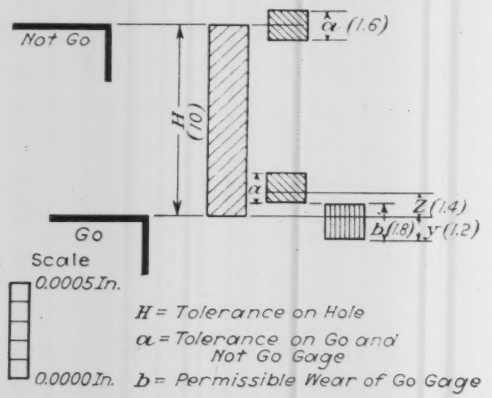
conditions would then have to be fulfilled actually to produce an incorrect fit of this type, as follows:

1 A slightly undersize hole must have been accepted by a "Go" plug gage worn past the low limit of the hole
2 A slightly oversize shaft must have been accepted by a "Go" snap gage worn past the high limit of the shaft, and
3 The undersize hole must happen to be mated with the oversize shaft, instead of other combinations occurring where the slight deviation of hole or shaft is of no consequence.

In practice, the chance that such coincidence will occur is so small—so the advocates of the standpoint in question reason—that it may well be neglected.

The former of the two standpoints discussed above—the "strict" standpoint—was represented in the I.S.A. subcommittee by the French delegates. It has also been adopted in the American Tentative Standard B4a-1925, which says on page 3:

> The extreme sizes for all plain limit gages shall not exceed the extreme limits of the part to be gaged. All variations, whatever their cause or purpose, shall bring these gages within these extreme limits.



ISA 3, FITS BETWEEN CYLINDRICAL PARTS
INTERNATIONAL PROPOSAL
NOVEMBER 1930

Fig. 5, Position of Manufacturing Tolerances on Go and Not Go Working Gages and of Permissible Wear of Go Gage, Relative to Limits of Work (Hole)

NOTE: The Values in Parentheses are Given in Tenthousandths of an Inch and Apply to a Grade 7 Hole with a Nominal Size Lying within the Subrange from $1\frac{1}{4}$ to 2 Inches Inclusive

FIG. 5 GAGE TOLERANCES AND WEAR

The more liberal standpoint—permitting a gage occasionally to have a size slightly outside the limits of the work—has been adopted in the national standard systems of Czechoslovakia, Germany, Sweden, and Switzerland. Here, the "Not Go" gages have a (symmetrical) bilateral tolerance on the "Not Go" limit of the work, and the sum of the tolerance on the "Go" gage and its permissible wear is distributed on both sides of the "Go" limit. For example, a German "Go" plug gage is made with a plus tolerance and may wear past the "Go" limit an amount equal (or about equal) to this tolerance.

The two standpoints have been thoroughly discussed in the I.S.A. subcommittee, and it was agreed in principle that the tendency should always be to avoid trespassing of the limits of the work. On the other hand, it was realized that the present status of the art of manufacturing gages and also the considerable investment in existing stocks of gages—made in accordance with the more liberal standpoint of the Continental systems—made it impossible rigidly to prohibit the trespassing of the limits of the work under all conditions.

The I.S.A. subcommittee therefore made a recommendation in this respect which is a compromise between the two standpoints discussed above. According to this recommendation—illustrated by the diagram in Fig. 5 applying to a "Go" and a "Not Go" plug gage taken as an example,

> The tolerance a on the "Go" gage is distributed equally on both sides of a line located within the tolerance on the work at a distance z from the "Go" limit. This line represents the size of the "Go" gage at which the gage manufacturer will aim;
>
> The permissible wear b of the "Go" gage extends from the minimum metal limit of the gage a distance y past the "Go" limit of the work;
>
> The tolerance a on the "Not Go" gage is distributed equally on both sides of the "Not Go" limit of the work, this being the size at which the gage manufacturer will aim in making the "Not Go" gage.

The values a, z, and b are laid down in the I.S.A. proposal. They have been adopted with the idea in mind that in principle trespassing of the work limits by the gage size should be avoided, but that it is not feasible at the present time absolutely to prohibit such trespassing on account of existing practice laid down in national standards. The numerical values given in Fig. 5 are those applying to plug gages used for checking a Grade 7 hole with a nominal size lying within the subrange from $1\frac{1}{4}$ in. to 2 in. (30 mm. to 50 mm.).

It is evident that if the I.S.A. proposal discussed here becomes adopted by a number of countries as a basis for their national standard system of fits, each country will have the facility, but not the obligation, to permit "Go" gages to wear a distance y past the "Go" limit of the work. In other words, a country opposed to letting the "Go" gage wear past the "Go" limit of the work could adopt the value *zero* for the distance y, whereas a country which permits such "extra" wear could adopt a positive value for y. For example, the present American Tentative Standard B4a-1925 is based in principle on the value $y = 0$.

No values for a, z, and b have as yet been laid down in an American national standard.

The increasing accuracy of gage manufacture and the increasing resistance of gage materials against wear, will tend to bring the two standpoints referred to above—the "strict" and the "liberal"—closer together. In fact, increasing accuracy of manufacture means a smaller value a, and a decreasing rate of wear practically means that the distance z can be reduced and that the extra amount of wear y becomes less necessary because a more resistive gage will have a longer useful life, even though its extreme limits are narrowed.

With a view to further progress in the art of gage making, the I.S.A. proposal recommends that the specifications for tolerances on, and permissible wear of, gages be given renewed consideration in the future, but not earlier than ten years from now.

The I.S.A. proposal specifies the grade of gage to be used for each grade of work, hole, or shaft. By way of example, Table 3 shows the relationship between the grade of a hole (nominal size between $1^1/_4$ in. and 2 in.) and the grade of the gages required for checking such hole. Table 3 contains the finer Grades 2, 3, and 4, which are reserved for gages and perhaps for future extra fine work. Grade 6 appears in Table 3 as the tolerance on the finest hole, and as the tolerance on the plug gage for the coarsest hole (Grade 11). Numerical values of the other dimensions are also given for the several grades of holes to visualize how the system works out in practice.

TABLE 3 RELATIONSHIP BETWEEN GRADES OF HOLES AND GRADES OF CORRESPONDING PLUG GAGES

(Dimensions in ten-thousandths of an inch)

Hole (from $1^1/_4$ in. to 2 in., incl.)	Grade 6	Grade 7	Grade 8	Grade 9	Grade 10	Grade 11
Plug Gage ("Go" or "Not Go")	Grade 2	Grade 3	Grade 4	Grade 5	Grade 5	Grade 6
Tolerance H on hole	6	10	18	32	48	68
Tolerance (a) on plug gage	1.2	1.6	2.8	4.4	4.4	6
Permissible wear (b) of "Go" plug gage	1.2	1.8	3.0	4.2	4.2	5.8
Distance (z)	1.0	1.4	2.4	4.4	4.4	8.8

For snap gages the numerical values are the same as those for plug gages of corresponding size and grade, only the position of the tolerance and of the permissible wear relative to the "Go" limit of the work is of course the opposite of that applying to plug gages.

INCH AND METRIC UNITS

In the I.S.A. proposal the numerical values of tolerances and allowances are given in microns exclusively. One micron equals 0.001 mm., or, with very close approximation, 0.00004 in. The latter conversion value is adopted in the above report and the micron values given in the I.S.A. proposal are converted to values in ten-thousandths of an inch. This conversion is based on the ratio: one "tenth" equals 2.5 microns, but it is possible that ultimately a closer approximation to the exact ratio 2.540005 should be used. This ratio is based on the relationship between the inch and the millimeter as officially adopted by the Bureau of Standards, that is, one inch equals 25.40005 millimeters.

QUESTIONNAIRE

To assist the members of the Sectional Committee B4 in forming their opinions concerning the several parts of the I.S.A. proposal of November, 1930, the following questions have been framed:

1 Do you agree with the proposal that the reference temperature for limit gages, etc. be 68 deg. fahr. (20 deg. cent.)?

2(a) Do you agree with the proposal that for the time being nominal diameters up to 180 mm. (about 7 in.) be dealt with, this range to be extended later to 500 or 600 mm. (about 20 to 24 in.)?

(b) Which of the two upper limits of the extended range of diameters would you prefer, 20 in. or 24 in.?

3 Do you agree with the proposed subdivision of the range of diameters up to 180 mm. (about 7 in.) into subranges for each of which tolerance and allowance values are kept constant?

4 Do you agree with the principle that the numerical values of tolerances and allowances are determined on the basis of practical data, abandoning for the present time any effort to establish a mathematical law governing these values?

5 Do you agree with the proposal that the Basic Hole and the Basic Shaft System be adopted side by side as standard systems?

6 Do you agree in principle with the proposal that unilateral tolerances be adopted?

7(a) Do you agree with the proposal that the designation "grade" instead of applying to a complete fit—that is, to the combination of a hole and a shaft—shall apply to the individual holes and shafts?

(b) Are you in favor of establishing standard sheets giving series of fits (for example, hole H 7 combined with the shafts p 6 to g 6, f 7, e 7, and d 8) similar to those given on the standard sheets so far adopted in Europe? (See Figs. 1 and 2.)

8(a) Do you agree with the proposal that the grade of a hole or shaft be designated by a numeral?

(b) Do you agree with the proposal that the numeral 5 be assigned to shafts of the finest grade, the numerals below 5 being reserved for manufacturing tolerances on limit gages and for closer tolerances on work that may become necessary in the future?

(c) Do you agree with the proposal that letter symbols be used for the designation of the individual tolerances, capitals to be used for hole tolerances and lower-case letters for shaft tolerances?

9 Do you agree with the proposal that in cases where both the symbol for a hole and a symbol for the mating shaft are used—for example, for indicating a fit on a drawing—the symbol for the hole be mentioned first?

10(a) Do you agree with the proposal that in principle the limits of the work shall be represented by the nominal sizes of the working gages?

(b) Should inspection gages also be given consideration in the proposed I.S.A. system, in addition to working gages?

11 Do you agree with the proposal concerning the position of the manufacturing tolerances and the permissible wear of working gages, relative to the nominal limits of the work?

12 Do you wish to make any suggestions for changes or additions?

These questions outline the information and data which the Committee will want to develop for transmission to the I.S.A. Technical Committee No. 3 on Fits following the former's meeting in New York next October.

U.S. SERVICE RIFLE CAL..30, MOD. 1903
GARAND SEMI AUTOMATIC RIFLE CAL..276
PEDERSEN SEMI AUTOMATIC RIFLE CAL..276
GARAND SEMI AUTOMATIC RIFLE CAL..30

U. S. Service and Semi-Automatic Rifles

Development of Semi-Automatic Rifles

Work of the Small Arms Division, Manufacturing Service, of the U. S. Army Ordnance Department in Developing a Weapon That Will Automatically Eject the Case of a Fired Cartridge and Reload Itself With a Fresh Cartridge—Features of the Garand and Pedersen Rifles

By JULIAN S. HATCHER,[1] WASHINGTON, D. C.

FOR a great many years the Ordnance Department of the U. S. Army has been trying to develop a semi-automatic rifle. As long ago as sometime in the eighties it was said, in connection with a certain report on magazine rifles, that pushing the development of a magazine rifle was not then urgent owing to the fact that very probably before long a semi-automatic rifle would be perfected. This was half a century ago, but a satisfactory military semi-automatic rifle has not as yet appeared.

[1] Major, Ordnance Department, U. S. A.

The Ordnance Department has been actively engaged in trying to produce a semi-automatic rifle for a quarter of a century. Several promising models have been brought out, but as yet there has been nothing produced that has been deemed worthy of adoption.

It seems from this that the semi-automatic rifle must be a particularly difficult device to produce. The question naturally arises in the minds of the layman, "What is a semi-automatic rifle?"

This can perhaps best be explained by first describing briefly the gun that is used in our service. The present

Army rifle is what is known as a magazine rifle or repeating rifle. The gun has a magazine in which five cartridges are placed. After one cartridge is fired the mechanism of the rifle is operated by hand, and this manual operation results in ejecting the old cartridge case and feeding a live cartridge into the chamber, ready to fire.

The mechanical operation of opening the gun, ejecting the old cartridge case and shoving in a new cartridge, and closing and locking the gun again, cannot be performed without a considerable muscular effort on the part of the soldier, with resulting motion which is very likely to apprise the enemy of his position. At the very best, the result of this muscular effort is that it causes the soldier to lose his line of sight.

What a Semi-Automatic Rifle Is

The self-loading or semi-automatic rifle is one that utilizes part of the energy in the cartridge to perform these mechanical operations as soon as the trigger is pulled. Thus, when the soldier fires the gun it immediately ejects the old cartridge case and reloads itself with a new cartridge, and all this is done without any muscular effort on the part of the soldier, and so quickly that the aim is not disturbed.

One of the greatest difficulties in training raw recruits to handle a rifle properly is teaching them to smoothly and rapidly execute the motions necessary to throw out the empty cartridge case and put the new cartridge in. If part of the surplus power of the gun is utilized to do this job automatically, it simplifies the training problem; moreover it renders the user of the rifle more effective because, once having located a point to aim at, all he has to do is press the trigger, and if he sees that the shot goes to the right or left he merely corrects his aim and fires again without entirely losing sight of the object as he would if he had to turn up and pull back the bolt of the Springfield rifle to eject the old cartridge case, and then shove the bolt forward and turn it down, to put in the new cartridge.

The likelihood of aircraft attack on columns of troops in future warfare furnishes a very strong reason for arming our soldiers with a semi-automatic rifle. It is particularly hard to fire several shots in succession at rapidly moving objects, such as aircraft, with any accuracy of aim when using a magazine rifle where the bolt has to be operated by hand before every shot. The problem is greatly simplified if a rifle reloads itself every time the trigger is pulled.

Self-Loading Principle Applied in Early Machine Guns

The self-loading principle has for many years been applied to machine guns, but this is much easier than to apply it to a shoulder rifle. The machine gun is a large, bulky piece of mechanism and there is plenty of space in which the inventor may put machinery, and as weight is relatively unimportant, he can do this without making the gun too heavy.

The first machine gun was invented by Sir Hiram Percy Maxim in 1884, and is still used in much the same form as he originally introduced it. Maxim was an American, and some years earlier was traveling in Europe demonstrating electrical apparatus. While there he was much impressed by the tremendous amount of money spent by European countries on armament, and when he remarked on this some one said to him, "If you want to make money, quit fooling with electricity and teach the Europeans how to cut each other's throats quickly and more effectively and you will have no trouble selling them your invention."

Maxim decided that this was good advice, and as he had noticed the terrific recoil of the Army rifle, he thought some of this could well be utilized in reloading the weapon after each shot. The result was the famous Maxim gun.

A short time afterward another American inventor, John M. Browning, of Ogden, Utah, also decided to devise an automatic gun, but instead of making the kick of the gun do the work, he drilled a small hole into the barrel so that part of the gas, instead of impelling the bullet forward, would rush out of this hole, impinge on a lever, and so operate the gun.

Recoil-Operated and Gas-Operated Guns

The Maxim gun was known as a recoil-operated gun, and the Browning as a gas-operated one. These two systems, recoil operation and gas operation, have persisted to the present time as the principal methods of supplying power to automatic guns.

As explained above, however, it is quite a different matter to make guns like these, which are mounted on separate carriages and are free from space and weight limitations, from what it is to make a gun light and compact enough to be carried by a soldier and capable of being fired easily from the shoulder, and yet contain all the complicated mechanism necessary.

The ordinary Springfield rifle weighs $8\frac{1}{2}$ lb., and when it is considered that most of this weight is in the barrel and stock, it will be seen that it is very difficult to make an automatic gun which will be no heavier. However, the military authorities are loath to consider an automatic gun which weighs more than the Springfield shoulder rifle.

Soon after the invention of the Maxim machine gun, attempts were made to produce a shoulder rifle operating on the same principle. Certain hunting rifles are built in this way, but it is a very grave disadvantage to have the barrel of the shoulder rifle loosely mounted so that it can slide back when a shot is fired. It means that there must be some support for the barrel, usually all the way out at the muzzle, and this support adds a great deal to the weight.

Moreover when a semi-automatic rifle is fired rapidly the barrel gets extremely hot, and a relatively small number of shots will suffice to make the barrel red hot unless it is made fairly massive. This adds to the difficulty of producing a successful recoil-action gun, because every ounce possible must be placed in the barrel to make it heavy, and in a recoil-action gun part

of this weight is taken away and utilized for a barrel support.

Another disadvantage of a recoil-action gun is the fact that it is not well suited for use with a bayonet.

As mentioned above, there are some successful recoil hunting rifles on the market, but they are fairly low-powered as compared with a military rifle.

The gas-operation system has also been repeatedly tried for shoulder rifles, but it has numerous serious disadvantages. In the first place, it must have a hole bored into the barrel; this hole cannot be cleaned well and is usually a starting place for corrosion, which ruins the accuracy of the barrel.

Then there must be some kind of piston extending from the breech action out along the barrel to where the gas port is located, and this piston must be protected by a cylinder or some other form of housing. As explained above, every ounce of weight possible should be placed in the barrel, and taking much of it away for pistons and gas cylinders leaves the barrel too small. Moreover the piston and gas cylinder are constantly clogging up with powder fouling, and in consequence are disagreeably subject to corrosion.

Some hunting rifles have been constructed on this principle but without success, and the chances are that a like fate awaits a military rifle employing the gas-operation system.

The Blow-Back System of Operation

There is still a third method of operating which is sometimes called the "blow-back system." In this the breech block is fairly massive and is merely held against the cartridge by the weight of a heavy spring, and not locked as the breech mechanism always is in the hand-operated magazine action and in recoil-action and gas-action guns.

This gun depends upon the inertia of the breech block to keep the breech shut until the bullet has left the barrel and the powder pressure has dropped. If the breech is not kept firmly shut until the powder pressure has dropped fairly low in the chamber, the result will be that the cartridge will either be blown to pieces by the gas pressure as soon as the action is partly open, or else part of the cartridge will stick in the chamber and the rear end will be blown off.

Experiments have proved that the inertia of the blow-back type of breech is satisfactory only when the weight of the breech block is properly proportioned to the weight of the bullet. Almost all automatic pistols are made on the blow-back principle and also the small .22 caliber automatic rifles which are so popular. There are also medium-powdered hunting rifles made on the blow-back principle which have been on the market some years. These, however, are rather clumsy owing to the comparatively large amount of weight necessary in the breech block.

In these blow-back guns, at the time of the explosion the cartridge is resting against the movable breech block, which is fairly heavy. When the powder is ignited the gas pressure pushes equally in both directions: that is, forward against the bullet and backward against the cartridge case and consequently the breech block. If the bullet and the breech block had the same weight the breech block would travel backward as fast as the bullet went forward, and the gun would do as much damage to the firer as to the one at whom he was shooting.

However, the breech block is much heavier than the bullet and therefore the bullet goes forward much faster than the breech block goes back, and before the latter has moved very far the bullet is out of the muzzle of the gun and the gas pressure has dropped considerably. However, the energy imparted to the breech block is sufficient to cause it to move to the rear against the action of the spring and pull out the cartridge case. As the breech block moves forward again it shoves a fresh cartridge into the chamber of the gun.

It has been found from calculation and experiment that to make a blow-back gun which will work satisfactorily with the Springfield-rifle cartridge, it is necessary to have a breech block weighing approximately 27 lb. As the entire weight of the gun, breech block, and all is limited to 8½ lb., it will be seen that the blow-back system is impracticable. However, a modified blow-back system is quite possible, and in fact the most successful semi-automatic rifle to date, the Pedersen, has been made on this principle, as will be explained later.

Another system of operating semi-automatic rifles is to have a small movable cap or cylinder fitted over the muzzle of the gun so that it can slide forward a short distance. This cylinder has a hole in it through which the bullet passes when it leaves the barrel. Some of the gas under high pressure passes out along with the bullet and pushes this cap forward to the limit of its motion, which is usually less than half an inch. A wire or rod fastened to the cap and extending back to the breech unlocks the breech mechanism through the forward movement of the cap.

A very clever semi-automatic rifle embodying this principle was invented by S. H. Bang, superintendent of the Danish Government Small Arms Factory. It was submitted to our Ordnance Department in 1911 and passed a very creditable mechanical test, but it was clumsy and had a number of undesirable features so that it never was adopted. Recently Mr. Bang submitted a second rifle, but it had the same defects that the first one had.

The Blish Principle

For quite a few years an effort was made to produce a semi-automatic rifle on what was known as the Blish principle. This principle, which was patented by Commander Blish, U. S. Navy, is based on the supposition that when two sliding surfaces of metal are forced together by a very heavy pressure, they will lock tight and will not slide, but that when the pressure is reduced to a certain point, sliding will start.

This is the principle on which the Thompson automatic rifle was built. In this the breech bolt is held

closed by means of a thread so steep that pressure on the front of the bolt will unscrew it. It was thought that the very heavy pressure of the cartridge on the front of the bolt when the cartridge was first fired would lock the threads together tightly, and that when the pressure dropped to a low figure the bolt would suddenly start to operate.

There has been some dispute among engineers as to the correctness of the supposition underlying the Blish principle. Some of them assert that the coefficient of friction is not modified by the pressure, and that as soon as pressure comes on the threads at all the bolt begins to move, but because of the mechanical disavantage it has in unscrewing, the time lag is sufficient to allow the bullet to get out of the barrel. In other words, it is claimed that this is merely a retarded blow-back action.

The Thompson gun was tested by the Ordnance Department on several occasions, but while it operated very well at times, it was always necessary to lubricate the cartridges, otherwise they would tear in two or stick in extracting just as cartridges do in a blow-back gun where the breech block is too light. This blow-back Thompson gun had a very long receiver which made the gun feel poorly balanced, and this poor balance, as well as oiling of the cartridges, has militated against its adoption by our services up to date, though it is possible that some modification might be made which would eliminate these undesirable features.

Some time ago Paul Mauser, inventor of the famous Mauser rifle, spent a number of years trying to devise a semi-automatic rifle based on the principle of having a sliding weight attached to the gun, so arranged that the weight would stand still because of its inertia as the gun recoiled on being fired. The relative motion between this weight and the gun was utilized to unlock the breech mechanism. For various reasons this gun never was successful enough to be adopted, one reason of course being that the addition of a heavy part, such as the inertia weight above referred to, adds to the difficulty of the inventor's problem of producing a gun that will be sufficiently light.

The Ordnance Department undertook the development of semi-automatic rifles as far back as 1906, but up to the time of the World War this effort had resulted only in the production of two gas-operated models, neither of which held much promise.

During the World War a designer from one of the commercial arms factories was commissioned a major in the Army and worked for about two years on the semi-automatic-rifle problem. He devised several gas-operated guns, but none of them was promising enough to warrant a service test.

The Garand Rifle

After the World War the Ordnance Department attacked the problem in earnest. An inventor, John C. Garand, who had submitted models of great promise, was employed by the Government, and later one of the foremost American commercial arms designers, J. D. Pedersen, was retained to develop a semi-automatic rifle which he already had worked out in principle. Mr. Pedersen is well known in arms circles as the inventor of the Remington pump shotgun, and of numerous Remington repeating rifles, the Remington automatic pistol, and the so-called .30 caliber pistol, Model 1918 (known as the "Pedersen device," an automatic bolt for the Springfield rifle, developed during the war and kept secret until this year). Both of these designers carried on their work at Springfield Armory and have continued developing their respective designs up to the present time.

The Garand rifle was first made on what is known as the primer-actuated system, which differs from the systems already described. There was a small moving weight inside the breech block, and the firing pin rested against this weight. When the primer was struck the firing pin was allowed to move back a short distance, and in so doing it threw the weight to the rear and the inertia of this weight unlocked the bolt.

The early models of this primer-actuated gun worked very well, but a change was made in the ammunition involving the use of a more progressive powder: that is, one which burns more slowly and whose maximum pressure does not occur so soon after the trigger is pulled. This change in ammunition threw Mr. Garand's early guns out of balance and they would not operate, and in consequence he abandoned the primer-actuated system and went to gas operation.

The Garand gun shown in the illustration has an extremely simple mechanism with a turning bolt securely locked in place until the impact of the gas on the piston unlocks it. This gun is subject to disadvantages like all other gas-operated guns. It has a gas cylinder hung from the bottom of the barrel, and the piston, lying underneath the barrel, adds weight to the muzzle, thus disturbing the balance of the weapon and rendering it less compact and handy than it would otherwise be. There is, moreover, more or less danger of trouble from powder fouling due to the accumulation of carbon in the gas cylinder.

The Pedersen Rifle

The Pedersen rifle is also constructed on an entirely new principle—in effect, it is what may be described as delayed blow-back. Its breech block is hinged in the middle so as to act as a toggle joint. If the joint of this toggle were exactly in line with the thrust of the cartridge the gun would never open, but it is slightly out of line so that as soon as the thrust of the cartridge comes, it starts to open the bolt. The thrust has to work at a mechanical disadvantage, and therefore cannot open the bolt so quickly. Moreover the joint of the toggle is not a hinge but a series of cams so arranged that as the joint breaks the cams roll on each other and keep the point of contact close to the line of thrust for an appreciable length of time, thus forcing the thrust to work at a mechanical disadvantage longer than it otherwise would, further delaying the opening of the gun. This system has the very marked advantage of having a fixed barrel with no gas cylinder or heavy piece of

mechanism attached to it for the purpose of unlocking the breech. The breech is simply balanced so that it unlocks itself at the proper speed.

The Pedersen gun requires the cartridges to be lubricated with a slight film of wax in order to operate with certainty. There has been some objection to this waxing of the cartridges on the ground that the wax might deteriorate and that it might pick up dirt. On the other hand, it is claimed that the waxing will preserve the cartridges by preventing corrosion which causes season cracking to start. It is further claimed that the wax used can be made so that it will not pick up any dirt, and can be applied in such a thin layer that its presence will not be noticed.

Twenty samples of this Pedersen semi-automatic rifle were made several years ago and sent to the services for trial, where they passed a very satisfactory test.

Last summer, in July, a board meeting was held at which inventors at large were invited to submit samples, but the board found the Pedersen rifle and the new Garand rifle were the most promising. As a result of this meeting twenty of the new Garand rifles and twenty Pedersen rifles have been sent out for actual use by troops as a service test.

Both of these rifles appear very promising, but the test will probably reveal that they are not perfect. An obvious disadvantage is that the cartridges come from the factory in steel clips and the clip is put into the gun along with the cartridges. When the last shot is fired the clip is automatically ejected and the breech stays open ready for the insertion of another clip.

This so-called "block-clip" system of loading the rifle makes for rapidity in fire, because as soon as the last shot is fired the user of the gun is automatically notified by the fact that the gun remains open. All he has to do then is to drop in another clip of ten shots, shut the breech and resume firing.

However, this block-clip system has one disadvantage, and that is that the gun will not operate without clips. The Springfield rifle has a magazine, and the cartridges are placed in clips for convenience in loading the magazine. To load the Springfield, the cartridges are stripped out of the clip into the magazine, where they remain, while the clip is thrown away. With the Springfield, if the rifleman runs out of ammunition specially loaded in clips, he will probably be able to find some machine-gun ammunition which is not in clips, and it is a very easy thing to place machine-gun cartridges in the magazine of the rifle up to the number required to fill it.

This is not true of the Garand and Pedersen semi-automatic rifles. Without the clips these guns cannot be used, and therefore if the firer uses all of his rifle cartridges packed in clips but still has machine-gun cartridges available, he cannot use them because they will not feed from the magazine without a clip to guide them.

Whether or not either one of these two guns is to be adopted will probably be determined in a few months, and if either one of them is successful it will end an intensive effort of twenty-five years to develop a gun of this kind. In all this time the progress that has been made has been relatively small, as the guns tested early in the period in many cases closely resemble those which were in the test last summer.

Helium

HELIUM had a density of 1.9885, and its boiling point as determined by Kamerlingh Onnes is —268.9 deg. cent., at which the density of the liquid is 0.125. It has been frozen to a solid by subjecting it at this temperature to a pressure of 100 atmos., while by subsequently evaporating it, a temperature of less than 1 deg. absolute has been attained. By the aid of liquid helium Kamerlingh Onnes has demonstrated the superconductivity of certain metals, the resistance of which to the passage of a current vanishes at these low temperatures, so that a current once started in them will continue to flow for hours or days.

The fact that helium is associated with radioactive minerals early led to the surmise that it was itself a radioactive product, and in 1903 this was definitely proved by Ramsay and Soddy. At quite an early date Lord Rutherford convinced himself that the α-particles which were shot out of radioactive atoms at speeds of the order of 10,000 miles a second were identical with helium nuclei. Probably all the helium on earth was thus derived.

It was by studying the scattering of these charged particles of helium that Lord Rutherford was led to the nuclear theory of atomic structure, and he subsequently showed that the atoms of certain of the lighter elements could be transformed by bombarding them with α-particles.

The helium nucleus is believed to consist of four protons combined with two electrons. The "atomic" weight of this nucleus is 4.0011, while that of the four protons and two electrons in the free state is 4.033. The loss of mass is therefore 0.0289 per atom of helium formed. By Einstein's theory this loss of mass corresponds to an energy emission equal to $0.0289 \times c^2$, where c denotes the velocity of light. It thus appears that in forming 1 kg. of helium, the energy emitted is equivalent to 1.55×10^{14} gram-calories, or, say, to that liberated on the combustion of 20,000 tons of coal. The energy liberated in forming helium, however, appears in the first instance not as heat, but in the form of radiation.

Quite recently a very rich and apparently prolific source of helium has been discovered in Colorado, where natural gas, found at a depth of 950 ft. below surface level, proves to contain 7 per cent of helium. It seems probable, therefore, that in the near future considerable quantities may be available at a cost not much greater than that of an equal bulk of hydrogen.—From report of a lecture by Lord Rutherford, F.R.S., before the Royal Institution, in *Engineering*, Apr. 17, 1931, p. 505.

Patent Appeals

Proposal of a Single Court to Take Over the Final Jurisdiction of Patent Appeals Now Held by the Ten U. S. Circuit Courts of Appeals, and the Draft of a Bill Therefor

By EDWIN J. PRINDLE,[1] NEW YORK, N. Y.

BECAUSE of the peculiar nature of the patent monopoly, the present system of appeals in patent-infringement suits in the United States is the most inefficient, expensive, and wasteful to be found anywhere. It is a deterrent to the production of inventions, and to the investment of capital in patents. Correction of this condition is by far the greatest need of our patent system.

The Present System of Appeals, Its Nature and Defects

For the first century of our patent system there was a single court of patent appeals, and that was the Supreme Court of the United States. But this court became so overburdened with work that, in 1891, the appeal to the Supreme Court was taken away, and the country was divided into nine circuits (now ten), each of which was provided with a Circuit Court of Appeals, which has final jurisdiction of all patent appeals in its circuit.

These courts are independent of each other. While under the doctrine of comity, unless they see substantial reasons for not doing so, they follow a previous decision by the court of appeals of another circuit on the same patent, still they are at liberty to decide oppositely, and frequently do so. Each court of appeals is supreme in its own circuit, so that there are, in effect, ten independent supreme courts for patents.

"A patent may be valid in one circuit and invalid in another. It may have been given a broad, inclusive interpretation in one circuit, and a narrow one in another. It may be infringed by a given construction in one circuit, and not infringed by the same construction in another. A defendant in whose favor a patent has been held invalid, or not infringed, in one circuit, is free to make, use, and sell in every other circuit; and the patentee cannot even enjoin his agents or customers. Thus in a single circuit, a patent may be invalid as to one person or corporation and valid as to every one else, or vice versa. Even if a patent has been sustained in two circuits, there are still eight circuits, any one of which could decide to the contrary; so that the standing of the patent still is in doubt and infringers still may be tempted to take the risk. . . .The only solution of the difficulty is a single Court of Patent Appeals."

As stated, there is no appeal to the Supreme Court. The only right is that of petitioning the Supreme Court to grant a writ of certiorari ordering the case to be sent up to it. The Supreme Court has such an enormous volume of work that it does not take up a patent case unless there is some question of public importance, or of interpretation of law, or unless the Circuit Courts of Appeals of two circuits have decided the same question concerning the same patent in opposite ways.

The decision of a single circuit court of appeals is final in most branches of the law (practically the only other exceptions being copyright and trademark matters), but it is not so as to patents.

The monopoly which a patent grants is a negative one. The patentee is not granted the right, himself, to make, use, or sell the patented invention—a *positive* monopoly. He already has that right because of his inventorship, unless in doing so he would have to use that which has already been patented to another. The patent merely grants him the *negative* right to exclude all others throughout the United States from making, using, and selling the patented invention. To be of any value to him, his monopoly must be maintained inviolate. If there is one infringer anywhere in the United States who has been rendered immune from the patent by a final decision, it will greatly impair and may largely destroy the value of the patent. One hole that cannot be stopped may sink a ship.

Under these circumstances, to make it necessary that the patent shall have been adjudicated oppositely in two separate circuit courts of appeal before the mere right shall exist to petition the one court which can render a final decision, the Supreme Court, to take it up, is a shocking economic waste.

A patent may be valid in one circuit and invalid in another. It may have been given a broad, inclusive interpretation in one circuit, and a narrow one in another. It may be infringed by a given construction in one circuit, and not infringed by the same construction in another. A defendant in whose favor a patent has been held invalid, or not infringed, in one circuit, is free

[1] Patent Lawyer, Prindle, Bean, and Mann. Mem. A.S.M.E. Dr. Prindle was graduated from Lehigh University in 1890 with the degree of M.E. Since then he has received the degrees of L.L.B. (1892), L.L.M. (1894), and L.L.D. (1930) from the National University. He was an assistant examiner in the U. S. Patent Office from 1890 to 1899, since which time he has exclusively practiced patent law. He is a member of the A.S.M.E., A.I.E.E., and A.I.M.E. He was president of the New York Patent Law Association in 1926–1927, and was proposed by that organization to President Coolidge for judge of the Court of Customs and Patent Appeals, but withdrew his name for economic reasons. He has been patent counsel to many corporations, and led the national organizations of engineers and manufacturers in legislative campaigns which procured increases of salaries in the Patent Office and for the Federal judiciary. He is the author of works on the theory of patent law; practical use of patents in manufacturing business; art of inventing, etc. He is chairman of the Patents Committee of the American Engineering Council.

to make, use, and sell in every other circuit; and the patentee cannot even enjoin his agents or customers. Thus, in a single circuit, a patent may be invalid as to one person or corporation and valid as to every one else, or vice versa. Even if a patent has been sustained in two circuits, there are still eight circuits, any one of which could decide to the contrary; so that the standing of the patent still is in doubt and infringers still may be tempted to take the risk.

If the first of two decisions by a different circuit court of appeals is against a patent, and the Supreme Court decides in favor of the patent, it almost invariably is too late for the decision of the Supreme Court to affect the first case; and the defendant in that case is free to infringe the patent throughout the remainder of its life, and throughout the whole country.

Furthermore, the statute provides that where the patent covers more than the patentee invented, he must, with reasonable promptness, file a disclaimer in the Patent Office, disclaiming that which is not his invention. Where in the first suit under the patent a court of appeals holds a claim to be invalid, it must be promptly disclaimed, under penalty of the patentee's losing the right to bring other suits under the patent. The law provides that the disclaimer becomes a part of the patent. It is effective throughout the United States in all circuits. Therefore, if another circuit court of appeals in a second suit on the same patent held the claims to be valid which were disclaimed in the first suit, and the Supreme Court then, on writ of certiorari, held the said claims to be valid, it almost invariably would be too late, under the statute, for the Supreme Court to afford relief. Thus the patent irretrievably would have been emasculated, because of the plurality of courts of appeals; while with a single Court of Patent Appeals, the validity of the claims could be finally determined before any disclaimer was filed.

Moreover, by the time the patentee has obtained a favorable decision in a second circuit in any of these cases, a large proportion of the short life of the patent (seventeen years) usually has expired, with no substantial reward to the inventor.

The expense of these repeated litigations makes them impossible to the individual, and constitutes a burden, from incurring which even the large corporations shrink.

With ten courts of appeals there are unavoidable differences of opinion on various points of law and differences of tradition as to the liberality or strictness of construction to be applied to a patent under the same circumstances. But, under a single court of patent appeals, the administration of the patent law would attain completeness and certainty, and uniformity of application in these and other respects, which it now lacks.

Patents also involve many difficult questions of science and engineering upon which judges may and often do differ, and thus it is impossible that the decisions of the various circuit courts of appeals on the same patent shall always be uniform.

Quite as many of the patents that are adjudicated are held to be invalid as are sustained. Both the public and the patentee, therefore, need to know, early in the life of the patent, whether or not the patent is valid, and what is its scope. If the patent is invalid the public should know it, and not be kept in uncertainty for years, during which it would have been free to use the alleged invention described in the patent if a single final decision could have been obtained. On the other hand, if the patent is valid the patentee early in the life of his patent should have a single decision which applies throughout the United States and which will hold against all subsequent defendants, unless they set up defenses which are substantially different from those considered in the first suit, or unless they use a structure which does not come within the monopoly of the patent as determined in the first suit.

The patent should be adjudged as to validity, scope, and infringement on the same principles and policy throughout the United States, both for the sake of the public and the patentee.

The head of the patent department of one of the largest corporations in this country said to the author recently, "Whether a patent is valid or invalid, we want early in its life to know definitely, so that we may shape our course accordingly, and with confidence that the situation will not be changed during the life of the patent, except for substantial reasons."

Therefore, the only solution of the difficulty is a single Court of Patent Appeals.

PAST EFFORTS TO OBTAIN A SINGLE COURT OF APPEALS

In 1903 the American Bar Association approved the principle of a report of its Patent Committee recommending the establishment of a single Court of Patent Appeals, and directed the Committee to lay a bill for that purpose before Congress, and use its influence to secure the enactment thereof.

The particular bill then proposed was not approved, but the principle of a single court of patent appeals was approved, leaving the form of the bill open. Mr. Frederick P. Fish was chairman of the Patent Section, and vigorously advocated the bill.

The bill provided for a chief justice, appointed for life, and six judges to be designated from the circuit and district courts, to sit for terms of six years each in the court of patent appeals. But the attempt to pass the bill failed.

Another attempt was made to secure enactment of the same bill in 1919 when the author, as secretary of the Patents Committee of the National Research Council, again secured the introduction of the bill in the House of Representatives. The Patents Committee of the House granted a hearing on the bill, at which the patent bar, the manufacturers, the engineers, and eminent inventors were represented or appeared and advocated passing the bill. But the House Committee refused to approve the bill, because it became apparent that judges would not break up their homes and interrupt their friendships and their children's schooling and go to Washington merely for a term of six or, possibly,

twelve years. It became clear that appointments would have to be permanent to induce judges to become members of the Court.

THE RENEWED CAMPAIGN FOR A SINGLE COURT OF PATENT APPEALS

Meanwhile the need for a single court of patent appeals has constantly been growing. The author's long experience in the practice of patent law has convinced him that such a court is now a practical necessity, and that it would substantially stimulate inventing and would protect both the patentee and the public from enormous unnecessary expense.

The American Engineering Council, at the suggestion of the American Institute of Chemical Engineers, and on a report by the author, has recently approved renewing the legislative effort with a bill curing the former objections.

The National Association of Manufacturers, on the author's proposal, has again passed a resolution approving of the principle of a single court of patent appeals, and the undertaking of another campaign at this time to enact a bill for the purpose.

Various committees of patent-law associations are considering the advisability of a renewed effort to secure a single court of patent appeals.

PROVISIONS OF A PROPOSED BILL FOR A SINGLE COURT OF PATENT APPEALS

The author has prepared a bill, a copy of which is attached hereto, which provides for a Single Court of Patent Appeals sitting at Washington, and composed of a chief justice and six associate judges, five of the seven judges to constitute a quorum. Not only the chief justice but the associate judges shall hold their offices, as the Constitution says, "during good behavior."

The court is to have final jurisdiction of all appeals in patent cases from the District Courts of the United States and from the Supreme Court of the District of Columbia, both in interlocutory and final orders and decrees, jurisdiction of the United States Circuit Courts of Appeals in patent appeals being abolished. The power of the Supreme Court of the United States to order cases certified to it, is extended to include the Single Court of Patent Appeals, and the right is given to that court to certify questions to the Supreme Court for instructions.

The salaries of the chief justice and the associate judges of the Single Court of Patent Appeals are set, respectively, at $13,500 for the chief justice, and $13,000 for the associate judges. These are higher than those of the circuit courts of appeals.

The Single Court of Patent Appeals, would therefore be of higher rank than the United States Circuit Courts of Appeals—the next in rank to the Supreme Court of the United States. This undoubtedly would assure that a sufficient number of the best-qualified judges in patent cases will be available for appointment to this court.

In order that the judges shall be specially qualified for the single court of patent appeals, the bill provides that "experience in the adjudication of a substantial number of patent cases on the Federal bench, or in the practice of patent law in the Federal courts, shall be requisite to appointment as chief justice or a judge of said court, to the end that only judges who have shown special aptitude for the adjudication or the practice of the patent law shall be appointed to said court."

The author believes, therefore, that the said bill is practical, that it would provide a court of judges who are thoroughly competent and experienced in the patent law, and that the prestige of the said court, ranking next to the Supreme Court, and the precedence in the official and diplomatic life in Washington, would not only attract a sufficient number of the best-qualified patent judges, but that the possibility of future appointment to that court would tend to increase the interest of judges of the United States District Courts in patent law.

The judges of the proposed single court of patent appeals would not only be well qualified, at the time of appointment, for adjudication of patent cases, but experience and observation show that, by the adjudication of many patent cases, they would acquire a facility for comprehending the science and engineering of patent cases which would enable them, to a much greater extent, to make a selection on their own judgment between the conflicting opinions of experts.

The bill changes the name of the Court of Customs and Patent Appeals to the "Court of Customs and Patent Office Appeals," and it does not provide for appeals therefrom to the single court of patent appeals.

However, an applicant for a patent in every case except where the Commissioner of Patents is a necessary party, i.e., in all *inter partes* cases, instead of appealing from the Commissioner of Patents to the Court of Customs and Patent Appeals, could reach the proposed single Court of Patent Appeals by appeal on a bill in equity filed in the Supreme Court of the District of Columbia, or, where the opposing party in the interference is not a resident of the District of Columbia, by an appeal on a bill filed in the District Court of the district of which his opponent is a resident.

The Court of Patent Appeals is given the power to prescribe the forms of records on appeals thereto.

The establishment of a single Court of Patent Appeals would not only be a great benefit to patentees and to the public, but would increase the effectiveness of patents, and prolong the productive portion of their terms. It would also substantially stimulate inventiveness and the building of businesses under patents.

The establishment of the Court of Customs Appeals, now the Court of Customs and Patent [Office] Appeals, affords a precedent for the establishment of a single Court of Patent Appeals.

The author believes it is entirely possible to secure the establishment of a single court of patent appeals at this time if sufficient support is given by those who realize the importance of our patent system to our country.

Attention is invited to the draft which follows of the proposed bill for a single court of patent appeals, the principal provisions of which have just been outlined.

IN THE HOUSE OF REPRESENTATIVES

A BILL

TO ESTABLISH A SINGLE UNITED STATES COURT OF PATENT APPEALS, TO CHANGE THE NAME OF THE UNITED STATES COURT OF CUSTOMS AND PATENT APPEALS, AND FOR OTHER PURPOSES

BE IT ENACTED by the Senate and House of Representatives of the United States of America in Congress assembled, that there is hereby created an United States Court of Patent Appeals, which shall consist of seven justices, of whom five shall constitute a quorum, and shall be a court of record with jurisdiction as is hereinafter limited and established. Such court shall prescribe the form and style of its seal and the forms of its writs and other processes and procedure as may be conformable to the exercise of its jurisdiction as shall be conferred by law. It shall have the appointment of the marshal of the court, who shall have the same powers and perform the same duties under the regulations of the court as are now provided for the marshal of the Supreme Court of the United States, so far as the same may be applicable. The Court shall also appoint a clerk, who shall have the same powers and perform the same duties now possessed and performed by the clerk of the Supreme Court of the United States, so far as the same may be applicable. The salary of the marshal of the court shall be $3500 a year, and the salary of the clerk shall be $5000 a year, both to be paid monthly in twelve equal payments. The costs and fees now provided by law in the Supreme Court of the United States shall be the costs and fees in the United States Court of Patent Appeals; and the same shall be collected, expended, accounted for, and paid over to the Treasury Department of the United States in the same manner as is provided by law in respect to the costs and fees in the Supreme Court of the United States. The Court shall have power to establish all needful rules and regulations for the conduct of its business within its jurisdiction as conferred by law.

SEC. 2. That the President of the United States, by and with the advice and consent of the Senate, shall appoint a chief justice and six associate justices of said United States Court of Patent Appeals, and as vacancies occur shall in like manner appoint others to fill such vacancies from time to time. The acceptance of one of said offices by a circuit or district judge of the United States shall vacate his office as circuit or district judge. Experience in the adjudication of a substantial number of patent cases on the Federal bench or in the practice of the patent law in the Federal courts shall be requisite to appointment as chief justice or an associate justice of said court, to the end that only judges who have shown special aptitude for the adjudication or the practice of the patent law shall be appointed to said court. Appointment to said court shall be during good behavior.

SEC. 3. That a term of the United States Court of Patent Appeals shall be held annually at the City of Washington, beginning on the second Tuesday of October in each year, and the same may be adjourned from time to time as the court shall order. If at any time for the meeting of the court a quorum of the justices shall not be present, the justices present may adjourn the court, and, if necessary, adjourn again from to time until a quorum appear. If at any sitting of the Court, the Chief Justice shall be absent, the associate justice senior in commission as a circuit judge, or senior in age in case of commissions of even date, shall preside. If no associate justice who has been a circuit judge shall be present, the associate justice senior in commission as a district judge shall preside. In case of commissions of even date, the justice who is senior in age shall preside. Upon a request of the Chief Justice, or a presiding associate justice of The Court of Patent Appeals, the Chief Justice of the United States shall designate a judge, or judges, of any Federal court to fill a temporary vacancy in the said Court of Patent Appeals. Until it shall otherwise be provided by Congress, the sessions of the court shall be held in a building or rooms to be provided by the marshal of the District of Columbia, under the direction and approval of the Attorney General of the United States. The court shall by order authorize its marshal to employ such deputies and assistants for himself and the clerk of the court, and such criers, bailiffs, and messengers as the business of the Court shall require, and to pay the salaries of such employees at rates of compensation not exceeding those paid for similar services in the Supreme Court of the United States, and to pay all other necessary incidental expenses of the court. The Chief Justice and each of the Associate Justices shall be entitled to employ a clerk, whose salary, at a rate not exceeding that allowed the clerks of the Chief Justice and associate justices of the Supreme Court, shall be paid as part of the expenses of the Court. The Court shall have power, in its discretion, to appoint a reporter and to fix by order his salary or other compensation and direct the form and manner of the official publication of its decisions.

SEC. 4. That the Chief Justice of the United States Court of Patent Appeals shall receive a salary of $13,500 per year. The Associate Justices of the said court shall each receive a salary of $13,000 per annum. All the said salaries shall be payable in twelve equal monthly instalments. The time during which any Justice shall serve in said court shall be deemed continuous service with that in any other court of the United States, before or after such service within the meaning and intent of Section 375 of Title 28 of the United States Code.

SEC. 5. That the United States Court of Patent Appeals shall have jurisdiction to hear and determine appeals from final judgments and decrees in the district courts of the United States and in the Supreme Court of the District of Columbia in cases arising under the laws of the United States relating to patents for inventions, and from final judgments and decrees in cases arising under the laws of the United States relating to patents for inventions rendered by any other court having jurisdiction under the laws of the United States to hear and decide such cases in the first instance: Provided, however, that it shall have no jurisdiction of cases originating in the Court of Claims nor of cases in which the Commissioner of Patents is a necessary party. All such appeals shall be taken within three months after the entry of the order, judgment, or decree sought to be reviewed. The practice, procedure, and forms to be observed in the taking, hearing and determination of such appeals shall conform to the practice, procedure, and forms observed in like cases in the Supreme Court of the United States, subject to such rules and regulations as shall be prescribed by the Court. The said Court shall have power to prescribe the forms of records on appeals thereto.

SEC. 6. That whenever, by an interlocutory order or decree in a district court of the United States, in the Supreme Court of the District of Columbia or other Court having jurisdiction under the laws of the United States to hear and decide in the first instance cases arising under the patent laws, in a case in which an appeal may be taken from the final decree of such court to the United States Court of Patent Appeals, an injunction or restraining order shall be granted, or refused, or continued, or vacated, or modified, or retained without modification after motion to modify the same, an appeal may be taken from such order or decree by the party aggrieved to the United States Court of Patent Appeals: Provided, That the appeal must be taken within thirty days from the service of notice of entry of such order or decree; and it shall take precedence in the Appellate Court; and the proceedings in other respects in the court below shall not be stayed unless otherwise ordered by that court, or the United States Court of Patent Appeals, or a judge thereof, during the pendency of such appeal.

SEC. 7. That the chief justice and the associate justices of the United States Court of Patent Appeals shall each exercise the same powers in term and vacation in the allowance of appeals, supersedeas orders, and other matters incidental to the jurisdiction and business of the Court as are now exercised by the Chief Justice and associate justices of the Supreme Court of the United States in relation to the business and jurisdiction of that Court.

SEC. 8. That the decisions of the United States Court of Patent Appeals in all cases within its appellate jurisdiction shall

be final, except that it shall be competent, as hereinafter provided, for the Supreme Court of the United States to require, by certiorari, or otherwise, any such case to be certified to it for its review and determination with the same power and authority in the case as though it had been carried by appeal from the trial court directly to the Supreme Court.

SEC. 9. That whenever any case shall have been certified from the United States Court of Patent Appeals to the Supreme Court of the United States, by certiorari or otherwise, it shall, upon its determination by the Supreme Court, be remanded to the district court of the United States or other court in which it originated for further proceedings to be taken in pursuance of such determination. And in every case determined by the United States Court of Patent Appeals upon appeal, the case shall be remanded to the District Court of the United States or other Court from whence it came, for further proceedings to be taken in pursuance of such determination.

SEC. 10. That all appeals in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall have been pending without hearing in the United States Circuit Courts of Appeals or other court of appellate jurisdiction for less than three calendar months prior to the taking effect of this Act, shall be transferred from such circuit courts of appeals or other courts to the United States Court of Patent Appeals and be heard and determined in that court as though they had been taken there from the trial courts by appeal without further payment for certifying the record or any new or additional docket or calendar fee; all other appeals and writs of error in cases in which appellate jurisdiction is by this Act conferred upon the United States Court of Patent Appeals which shall be pending in the United States circuit courts of appeals or other courts of appellate jurisdiction at the time of the taking effect of this Act shall remain and be heard and determined by the courts in which they may be pending, respectively, as though this Act had not been passed.

SEC. 11. That after the taking effect of this Act no appeal shall be taken from any district court or from the Supreme Court of the District of Columbia or other Court of the United States to any United States circuit court of appeals or other appellate court in any case in which an appeal may be taken to The United States Court of Patent Appeals under the provisions of this Act. If, in any case, it is found that no substantial question under the patent laws is raised by the appeal, the court may order that such appeal be sent to the circuit court of appeals having jurisdiction over the district in which the suit was brought, or the Court of Appeals of the District of Columbia, as the case may be; if any appeal shall be taken to any circuit court of appeals, or to the Court of Appeals of the District of Columbia, and such court shall find that such appeal involves a question arising under the patent laws of the United States, except in a case where the Commissioner of Patents is a necessary party, such court shall order such appeal to be sent to the Court of Patent Appeals, and no appeal shall be dismissed solely on the ground that the appeal has been take to the wrong court.

SEC. 12. Section 301a of Title 28 of the United States Code is hereby amended to read as follows:

> The title of the United States Court of Customs and Patent Appeals, created by Section 301 of this title, is hereby changed to The United States Court of Customs and Patent Office Appeals.

SEC. 13. Section 346 of Title 28 of the United States Code is hereby amended to read as follows:

> In any case, civil, or criminal, in The United States Court of Patent Appeals, in a Circuit Court of Appeals, or in the Court of Appeals of the District of Columbia, the Court may at any time certify to the Supreme Court of the United States any questions or propositions of law concerning which instructions are desired for the proper decision of the cause; and thereupon the Supreme Court may either give binding instructions on the questions and propositions certified or may require that the entire record in the cause be sent up for its consideration and thereupon shall decide the whole matter in controversy in the same manner as if it had been brought there by writ of error or appeal.

SEC. 14. Paragraph (*a*) of Section 347, Title 28 of the United States Code, is hereby amended to read as follows:

> (*a*) In any case, civil or criminal, in a circuit court of appeals, or in the United States Court of Patent Appeals, or in the Court of Appeals of the District of Columbia, it shall be competent for the Supreme Court of the United States, upon the petition of any party thereto, whether Government or other litigant, to require by certiorari, either before or after judgment or decree by such lower court, that the cause be certified to the Supreme Court for determination by it with the same power and authority, and with like effect, as if the cause had been brought there by unrestricted writ of error or appeal.

SEC. 15. That Sec. 377, Title 28 of the United States Code, be amended to read as follows:

> "Power to Issue Writs. The Supreme Court and the District Courts shall have power to issue writs of *scire facias*. The Supreme Court, the Court of Patent Appeals, the Circuit Courts of Appeals, and the District Courts shall have power to issue all writs not specifically provided for by statute, which may be necessary for the exercise of their respective jurisdictions and agreeable to the usages and principles of law."

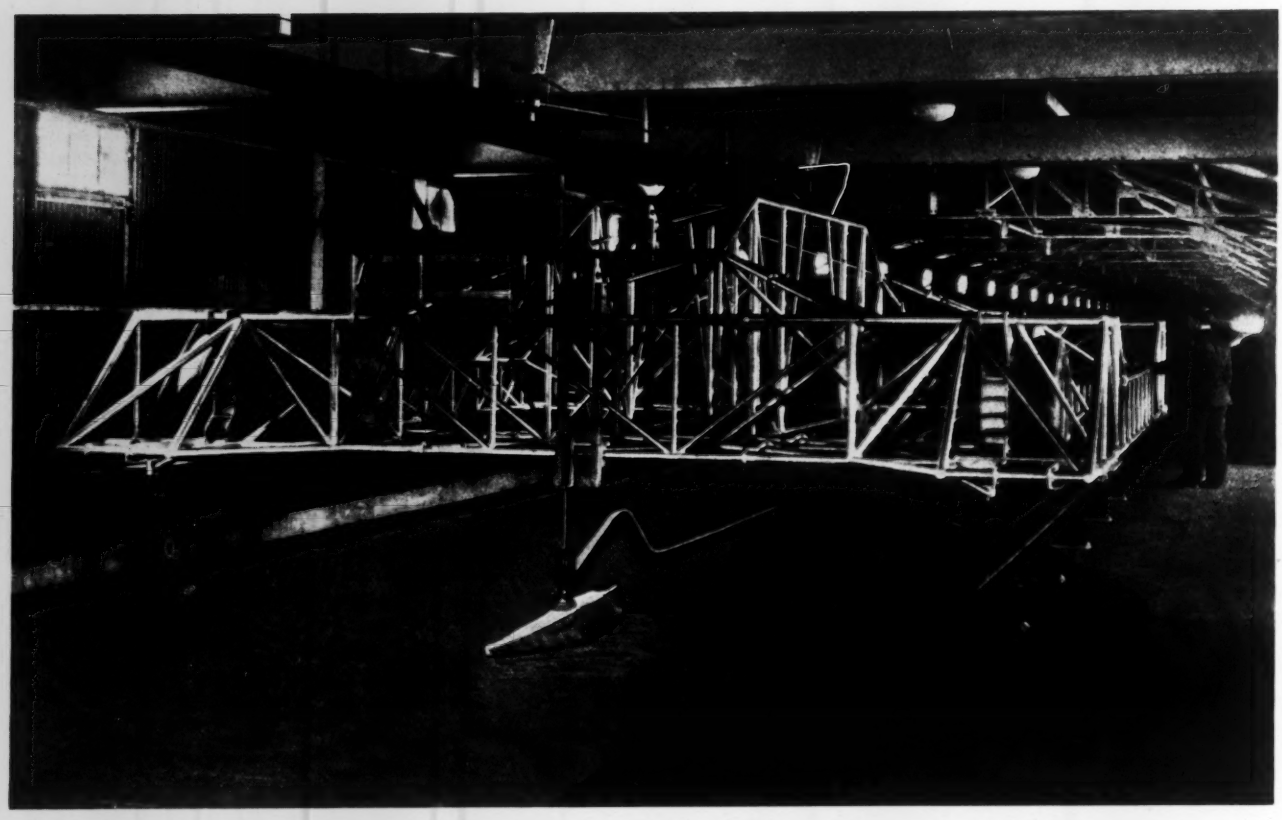
SEC. 16. That all laws and parts of laws inconsistent with the provisions of this Act are hereby repealed.

SEC. 17. That this Act shall take effect and be in force on the——day of———nineteen hundred and——.

The Spray Sherardizing Rustproofing Process

THE dry-vapor galvanizing or Sherardizing process, by which iron and steel and other metal articles are given a protective coating of zinc, was discovered by Mr. Sherard Cowper-Coles in 1900. The process consists essentially in heating the article to be coated to a temperature which varies with the class of article and the type of metal involved, but is usually in the neighborhood of 600 deg. fahr. in a rotating drum containing zinc dust. This material is a commercial product obtained during the distillation of zinc from its ores; it consists of very finely divided metallic zinc particles covered with zinc oxide. The Sherardizing temperature is well below the melting point of zinc. Articles after being Sherardized present a uniform and clean mat surface, light gray in color, and, of course, the great feature of the coating, from the point of view of protection, is that the deposited zinc is electropositive to the underlying metal. Should, therefore, an accidental scratch during service lay bare the base metal, the injury is subsequently healed automatically by electrochemical action.

A new development of some considerable importance is that known as spray Sherardizing or spray rustproofing. This process consists in spraying zinc dust on to structural-steel surfaces after erection is complete; it is stated to be suitable for coating bridges, buildings, roofs, ships, tanks, etc. The first step in the process is to clean the surface to be treated by means of steel brushes in order to loosen and remove all adhering dirt, old paint, rust, etc. A coating of bright-green bitumen-base paint is then applied by means of an ordinary paint sprayer, and when this has dried to the tacky stage, zinc dust is sprayed on, employing a pressure of a few pounds per square inch only. The bright-green tint of the paint forms a contrast with the gray color of the zinc dust, and the operator can be certain that he has covered the entire surface. The zinc adheres firmly to the layer of paint, and the whole becomes finger-dry in about two hours. After complete hardening, a tenacious and durable protective coating is obtained. Here again, owing to the fact that the zinc is electropositive to the underlying metal, rust does not spread beneath the coating. —*Engineering*, June 5, 1931, p. 750.



SEAPLANE TOWING CHANNEL AT LANGLEY FIELD

(The channel is 2040 ft. long, 24 ft. wide, and 12 ft. deep. View shows model of seaplane hull suspended beneath the motor-driven carriage. Towing speed, up to 60 m.p.h.)

Recent Aircraft Engineering Research

Wide Range of Work Reported at the Langley Field Conference in May—Particulars of the New Seaplane Towing Channel, 2040 Ft. Long at Langley Field, and Also of the Recently Completed Wind Tunnel at That Place, the Only One Yet Built in Which Full-Sized Airplanes Can Be Tested

BY ALEXANDER KLEMIN,[1] NEW YORK, N. Y.

THE Sixth Annual Aircraft Engineering Research Conference, under the auspices of the National Advisory Committee for Aeronautics, was held at Langley Field on May 27 last. As in previous years the conference was attended by many representative engineers of the aircraft industry, as well as by engineers and directing heads of the various Government air services. The conference has grown in interest and attendance year by year, so that an invitation is now highly prized, and owing to the increasing numbers of interested visitors it is possible that the conference may in future be divided into two distinct meetings, held a week or two apart. The plan of the conference included first of all an exposé of recent research work by members of the Langley Field staff, then a visit of inspection to the various laboratories of the field, a brief meeting at which engineers of the industry were asked to make suggestions for further research, and finally an interesting flight demonstration.

The National Advisory Committee undertakes a great deal of research work for the Army Air Corps and the Navy Bureau of Aeronautics, some of which is highly confidential. Visitors to the field were expressly asked to take no note of curves and data exhibited, and the results of experimentation must accordingly be referred to in rather general form.

[1] Daniel Guggenheim School of Aeronautics, New York University. Assoc-Mem. A.S.M.E.

CONTROL AT THE STALL AND STALLED LANDINGS

Summarizing an extensive series of tests on this topic, it may be said that all conventional airplanes, even though of good general design, have poor lateral control in the region of the stall, where the wing incidence is such that the maximum lift coefficient has been attained. The difficulty can be overcome by using the front slot in conjunction with the aileron, or by employing a tip aileron of the floating type. A study of spinning in full flight led to the conclusion that all airplanes can be spun, provided the elevator is powerful enough to raise the wing to such an angle of incidence that the wing tips are "stalled." When the elevator movement was so limited that the wing tips could not be stalled, the lateral control and stability became reasonably satisfactory at the highest angles of incidence and slowest speeds attainable. With limitation of the elevator movement and the resultant non-spinning characteristics, the airplane can be landed straight into the ground while gliding in a slow-speed attitude. The only precaution required is to provide the landing gear with a very long shock-absorber travel, particularly when landing in gusty weather, for a vertical gust has the ability of increasing the landing shock tremendously. The Verville Trainer when making a normal landing over a 50-ft. obstruction (by "normal landing" is understood one in which the airplane glides at a rather flat angle to the horizontal and is flattened out before impact to such an attitude that the front wheels and the tail skid strike the ground simultaneously) requires 600 to 800 ft. before coming to rest. The same Verville Trainer, when equipped with limited elevator travel and 13 in. travel in its shock-absorbing oleo strut needs only 400 to 500 ft. before coming to rest from the bottom of the 50-ft. obstruction. The shorter distance required may be attributed partly to the steeper glide in the slow-speed attitude, and partly to the lower landing speed and lesser kinetic energy at the instant of impact. The Verville Trainer results were extremely interesting as showing what can be done in this direction with a conventional airplane. When the airplane is provided with the front Handley Page slot and the rear flap, as in the case of the MacDonald Doodlebug (an entry in the Guggenheim Safe Aircraft Competition, purchased by the Committee for experimental purposes) the landing speed can be diminished by some 20 miles per hour, and the distance over the obstruction can be reduced to some 150 ft.

EXPERIMENTS WITH SLOTS

An intensive study has been made of the well-known Clark Y-section, fitted with the Handley Page slot. Over 100 different positions for the slot were tried. The maximum lift, in the best slot position, was increased by 43 per cent.

The main objection made against the Handley Page slot is that it introduces a movable part into the design of the airplane, and the introduction of movable parts seems to be taboo to the airplane designer. Accordingly the Committee undertook an investigation of the fixed slot, that is, one cut into the leading part of the wing, as a permanent opening. With the slot cut rather carefully into the Clark Y, the maximum lift was increased some 36 per cent and the minimum drag some 44 per cent. If a wing were used with such a fixed slot, the area could be reduced for a given gross weight and a given landing speed. The increase in minimum drag would thus be counterbalanced by the smaller dimensions of the wing and the performance would remain unchanged, or, if anything, would be slightly improved. This is therefore a promising result. A more practical use of the fixed slot is perhaps to be found in disposing it ahead of the ailerons only. The slot would improve the action of the ailerons at slow speeds or at the "stall." There is much to be said in favor of the fixed slot to be used in conjunction with the ailerons, particularly as such limited use would only cut down the top speed by some 2 miles per hour.

EXPERIMENTATION ON THE SPIN

The Committee is pursuing energetically both tunnel and full-flight experiments on spinning.

It has apparently been definitely determined that the incipient spin can be eliminated by the design of stable airplanes, well controlled at the stall. Full-flight experimentation indicates that one of the most important factors entering into the spin is mass distribution. Both the rapidity of the spin and the number of turns, with controls neutral, before the spin ceases are increased by unequal moments of inertia about the three axes of the airplane.

In the vertical tunnel, a six-component balance can record all forces and moments while the airplane model is in a condition simulating the spin. In the new 7-ft. $\times$ 10-ft. tunnel, the various coefficients can be measured directly by the simple expedient of keeping the airflow at a constant dynamic pressure, by a special pressure-electric device.

THE NEW PROPELLER-HUB DYNAMOMETER

The analysis of airplane performance always suffers from one gap, the actual power absorbed by the propeller in flight. A number of flight dynamometers have been employed in Europe and in the United States (at McCook Field, the former experimental station of the Army Air Corps). The principle frequently employed has been to mount the engine on hydraulic supports, and to measure the torque by recording the hydraulic reaction developed due to the engine torque. Such apparatus has been found cumbersome in practice. The N.A.C.A. in its new dynamometer has attacked the problem from a different point of view, by employing a closed hydraulic system between the crankshaft and the propeller hub, with three equally spaced hydraulic elements. The hydraulic pressure developed is transmitted to an indicating instrument provided with a flexible diaphragm to which a moving mirror is attached. The reflection of a light on the moving mirror is recorded on a film mounted on a drum revolving at a constant speed. The apparatus is light and

neat, and promises to be very useful in research work.

Load Distribution and Stress Analysis

The art of airplane stress analysis has developed very rapidly in the last few years. An analysis, however, though accurately and skilfully made, is no more reliable than the aerodynamic assumptions on which it is based. Much attention is therefore being given to the air-load distributions under various conditions of flight. An interesting result recently arrived at is that the concentration of air pressure at the extreme rear tip of a rectangular airfoil can be readily eliminated by slightly rounding off the tip. By special disposition of the rounded tip, the center of pressure of each element of the airfoil can be kept on a straight line as a locus. This is a practical point for the airplane designer, who has to calculate the strength of his two spars by assuming a certain position of the center of pressure between them, and dividing the load between the spars accordingly. A very useful formula, based on pressure-distribution tests, has been developed for the amount of the leading-edge loads. Since under certain conditions there is apt to be a very large concentration of load in the region of the leading edge, the calculation of such loads is important from a safety point of view. The calculation of tail loads is now being carried out more rationally. Instead of arbitrarily assuming a certain load on the tail surfaces, the aerodynamics of the cellule are very carefully determined, flight conditions studied, and the actual loads on the tail surfaces calculated.

Strength of Thin-Walled Cylinders

With the advent of the monocoque metal fuselage a really difficult problem in structural analysis has been presented to the airplane designer, namely, the strength properties which may be counted upon for the very thin sheet-metal covering. The theory is very difficult and the number of variables (thickness of skin, placing of bulkheads, ratio of bending moment to shear loads, design of longerons or stringers) is very large. Therefore the Committee has approached the problem from an experimental point of view, first utilizing paper cylinders to restrict the field of inquiry, and then passing on to celluloid and then finally to metal cylinders. An important result has already been obtained in the form of a curve in which the allowable fiber stress in bending is plotted against the ratio of bending moment to the product radius $\times$ shear. The failing stress in pure bending can now be corrected for various shear conditions. The allowable fiber stress of course falls off as shear is introduced in addition to the bending. The reports of the Committee on this topic will be awaited with much interest.

A Two-Cycle Direct-Injection Engine

The possibilities of a two-cycle aircraft engine, with direct fuel injection and electrical ignition, are rightly engaging the attention of many engine designers. The Committee has been experimenting with a single-cylinder engine of this type. At 700 r.p.m., a mean indicated pressure of 130 lb. per sq. in. was obtained, with the rather high fuel consumption of 1 lb. per hp-hr. The value of the two-cycle engine for aircraft use would lie in reduced weight for a given power. The use of direct injection would allow scavenging to be undertaken by a supercharged stream of air, with injection subsequent to the closing of the exhaust port so that there would be no loss of the incoming fuel. The difficulties in the two-cycle engine lie in the high scavenging pressure required and in getting rid of the excess heat developed.

Reduction of Fire Hazard

The Committee is giving much attention to the reduction of fire hazard. With the fuels in use today it has been found that 650 deg. fahr. is a safe temperature (from a fire-hazard point of view) for such a part as an exhaust manifold. The exhaust outlets of the engine have been surrounded with a sheet-steel venturi-shaped nozzle, acting after the manner of an air ejector and mixing cooling air with the exhaust gases prior to their entry into the exhaust ring. With the use of this cooling nozzle the temperature just outside the exhaust ring has been reduced from 1460 deg. to about 710 deg. fahr., or just a little above the safety point. The ejector-type exhaust manifold aroused much favorable comment among the visitors to Langley Field.

Another line of investigation pursued in the reduction of fire hazard was in the employment of a fuel with a higher flash point than ordinary aviation gasoline. Such fuels, made by the hydrogenation process, are somewhat difficult to carburet. Therefore the process to employing with such fuels would be that of resorting to an injection pump and an auto-injection valve. Preliminary results indicate that the brake m.e.p. falls off some 3 per cent with the use of the safety fuels, and the fuel consumption increases some 5 per cent. On the other hand, the safety fuels can be used at a higher compression ratio without risk of detonation.

Study of Combustion Phenomena in Direct-Injection Engines

According to the engine chief of the field, the problem of direct fuel injection has been largely solved, and attention is being concentrated on the problems of the combustion chamber, the ignition lag, the character of the fuel spray, etc. Quartz disks are now being employed for observation and photographic record of the phenomena of the combustion chamber, while pressure-indicator methods are not being neglected.

Landings With Locked Propeller

Pilots apparently have the impression that where a propeller is placed near the leading edge of the wing, slower landings can be made with locked propellers. The Committee's engineers gave an excellent explanation of this view. Their experiments have shown that a locked propeller does not have much effect on the lift of the wing, but that the combined drag of locked pro-

peller and wing is rather large. Therefore the glide path is somewhat steeper, and this gives the impression of a slower landing. It is likely that other pilot observations, correct in themselves, have an explanation totally different from the one attributed to them by even the experienced airman.

THE COMFORT OF THE PASSENGER

The Committee has been successful in developing a simple and inexpensive accelerometer, which can be used not only in a plane laboratory but in every-day transport planes. Records have already been obtained of accelerations in bumpy air in ordinary cross-country flying. The accelerometer should prove very useful in determining the type of plane likely to be disturbed least by bumpy weather.

AIRSHIP INVESTIGATIONS

The 20-ft. wind tunnel of Langley Field has been pressed into service to assist in the design of the large airship, U.S.S. *Akron*, now in process of construction by the Goodyear-Zeppelin Corporation. A $^1/_{40}$-scale model 20 ft. in length was tested in this tunnel for lift and drag of the hull, forces and moments on the elevator hinge post, etc. For accurate and rapid measurement of pressure distribution, 500 orifices on the hull of the airship were connected to a multiple-glass-tube manometer with circularly disposed tubes housed inside the airship. Readings were recorded by light flashes on photostat paper. During a 30-min. run, with various elevator settings, 8000 pressure readings were recorded.

There has been much controversy among airship designers as to the most appropriate fineness ratio. Deceleration tests with a number of airships in Europe and the United States seem to indicate that a fineness ratio of $6^1/_2$ to 1 will give the minimum value to the Prandtl airship drag coefficient. The British *R-101* and the *Los Angeles* seem to have the lowest drag coefficient to date, and the fineness ratio of both ships lies not far from this value of $6^1/_2$ to 1.

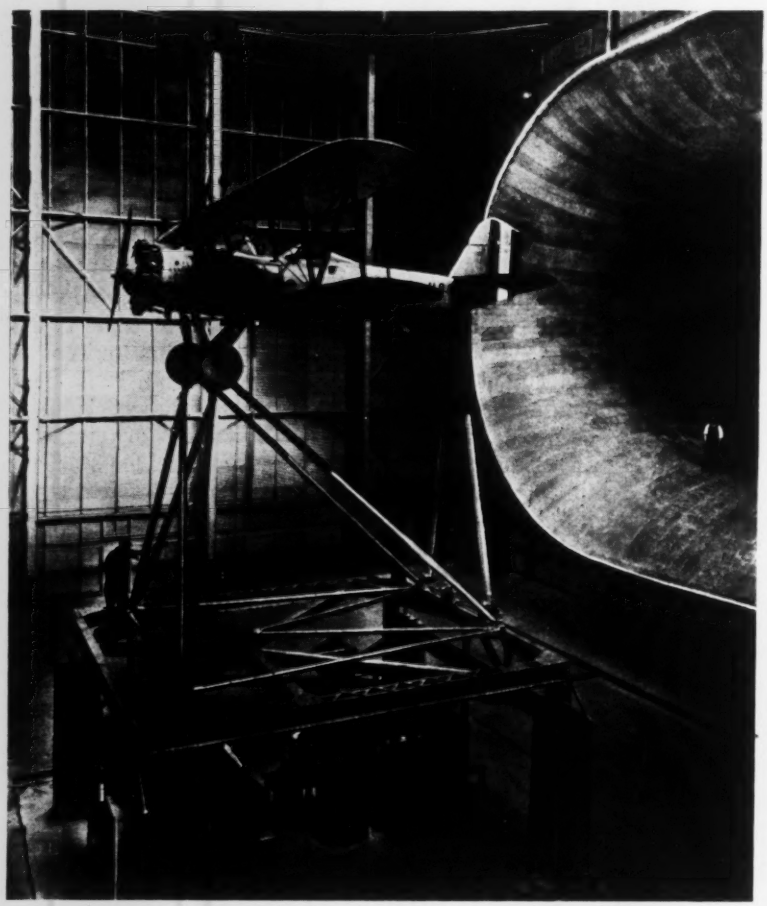
THE NEW SEAPLANE TANK

About sixty years ago an Englishman, William Froude, constructed a basin some 300 ft. long in which models of surface vessels could be towed at speeds up to 10 miles per hour. While none are more conservative than those engaged in marine transportation, the new test method introduced by Froude became almost immediately popular, and the towing basis has been widely used in England, Germany, France, and other countries with shipbuilding interests. The Washington Navy Yard has become deservedly well known, and at Washington all the important battleships and ocean liners built in the United States in recent years have been tested in model form. The Washington Navy Yard basin has also been widely used for the testing of models of seaplane floats and of flying-boat hulls. Unfortunately, in the Washington basin the length of run is such that 10 knots is the maximum permissible speed. Seaplanes may leave the water at 60 miles per hour, and a seaplane model tested at 10 miles per hour would therefore have to be built to a scale of $(^1/_6)^2$ or 1:36 in order to satisfy Froude's law (based on the theory of dimensional similarity). The models which it is possible to test at the Washington Navy Yard have therefore been somewhat too small for aircraft-design requirements. It was recognized several years ago that the building of a longer and speedier channel in the United States was imperative. On January 19, 1929, Dr. G. W. Lewis, Director of Research of the Committee, submitted a report to the Committee advocating the construction of a suitable channel, and shortly thereafter an appropriation of $280,000 was approved for this purpose by the Director of the Budget. The design of the channel was entrusted to Mr. Starr Truscott, of the Committee, and by January, 1930, a contract was entered into for its construction. The work of both design and construction has been unusually rapid. The tank, as described by Mr. Truscott at the formal opening, embodies many unusual and novel features in its design. It is 2040 ft. long, 24 ft. wide, and except for a short portion of its length at either end, 12 ft. deep. The towing carriage runs on pneumatic wheels, mounted on sturdy H-beam rails. The tank is of reinforced-concrete construction. The car is of welded-steel-tube construction. Each wheel is driven by a separate motor, and pole excitation independent of armature speed permits perfect speed control. At the side of the tank is a wide steel tape with slots at intervals. A light beam flashes through each of the holes, and the passage over a hole is recorded by means of a photoelectric cell, an amplifying system, and a recording drum. Thus a complete record of distance versus time—and hence of speed—is obtained. Lifting force, drag, and trim are recorded by balances similar to those employed at the Washington Navy Yard, and all readings are automatically recorded. The control of the motors is at a stationary control desk, but the carriage can be stopped by the observer riding on the carriage. While the observer need not record readings of the balances since these are automatic, he can make useful observations of the spray and character of the flow, and can also change trim of the model, etc.

THE LARGEST WIND TUNNEL IN THE WORLD

Dr. Joseph S. Ames, Chairman of the Committee, in his brief address when formally opening the tunnel, related a little-known incident in the life of Sir Isaac Newton, who, when investigating the laws of air resistance, measured his jump with and against the wind. The study of aerodynamics is therefore seen to be of quite respectable antiquity. Early methods of measuring air resistance involved the timing of fall for flat plates (as in the case of Eiffel who used the Eiffel tower for his observations). Langley used a whirling arm with considerable success. In 1890 Hiram Maxim built what was probably the first wind tunnel, 3 ft. square and equipped with balances. In 1901 the Wright brothers constructed a small wind tunnel, 18 in. × 18 in.

at the working section, and made many accurate and interesting observations of airfoils and propeller-blade elements. Since that date many wind tunnels have been built in the United States, in England, France, Germany, Italy, Japan, and other civilized countries. The first wind tunnel to be built at Langley Field was erected in 1919, and at present there are seven wind tunnels in full use at the field. The record for size in wind tunnels has been held by the large 20-ft. tunnel used mainly for testing propellers and in service for several years past at Langley. There are many advantages in being able to test a full-sized airplane in a tunnel, such as the elimination of scale effect, the possibility of introducing every last detail into the test, and the possibility of running a real engine and propeller. There is no particular difficulty in building a tunnel large enough to test a full-sized airplane: the problem is one of expense. The Committee is to be congratulated on securing an appropriation large enough for the construction of the new tunnel, which is the only one in the world capable of testing an airplane. No definite figures are available, but the total expenditure is said to have been in excess of a million dollars. The impression created on visitors to the new tunnel is one of awe—the awe inspired by a cathedral. One engineer said, "I don't believe it. It is all worked by mirrors."



THE LARGEST WIND TUNNEL IN THE WORLD

(Showing full-sized airplane mounted on floating platform at throat of wind tunnel, at Langley Field. The inlet cone is 60 ft. wide and 30 ft. high. Two 35½-ft. propellers, each driven by a 4000-hp. motor, when running at full speed force a continuous stream of air past the plane at a speed of 115 m.p.h.)

The tunnel is 434½ ft. in length and 222 ft. in width. The inlet cone is 60 ft. wide and 30 ft. high, so that the Chance Vought observation plane could be placed in the working section quite comfortably. The tunnel is of the double-return type, in the form of a very flattened figure of eight, with the working section (at which the highest speed is obtained) forming the central part of the figure of eight. The working section is of the open-throat type, so that access to the airplane being tested is very easy. The air is drawn past the throat by two 35½-ft. propellers, each driven by a 4000-hp. motor, streamlined in directly behind the propellers. At full motor speed, the tunnel stream attains a speed of 115 miles per hour. The motors have a speed range of 75 to 294 r.p.m., with control in 24 equal steps. The airplane is mounted on a floating platform, built up of structural steel and supported on streamlined tubular steel struts. The supporting struts, hinged top and bottom, rest on the lever arms of six balances, so that all six components of force and moments—lift, drag, side force, pitching moment, rolling moment, and yawing moment—can be measured simultaneously. The balances are automatic, and records are printed automatically on specially prepared slips, though an observer has to determine the moment when all balances are steady enough for accurate records to be taken. The platform carries a turntable, so that the airplane can be yawed through a range of —5 deg. to +25 deg., and the airplane can also be nosed down or pitched up by suitable manipulation of the supporting struts. Owing to the large electric load introduced by the tunnel, the new channel will only be run at night. It was most impressive to see the "pilot" climb aboard a movable ladder and seat himself in the cockpit, press a starter button, and "fly" his plane under conditions allowing every scientific observation.

One of the most practical events of the Langley Field conferences is the session devoted to suggestions for further research made by representatives of the industry. So comprehensive and wide is the program of research undertaken by the Committee, that the engineers present were loath to make suggestions this year, and remarks were very brief.

The Scope of Management in Our Future Business Development

Factors Essential in the Establishment of Good Management—The Real Duty of Management in Respect to an Individual Company and in Respect to the Industry of Which the Company Forms a Part

By J. P. JORDAN,[1] NEW YORK, N. Y.

WE HEAR much of the mechanization of industry. We hear that machines are taking the place of men. We hear that such replacement of men by machines is to blame for much hardship in the hard times we are now having. We hear all sorts of things about why we became overstocked, inflated, and all such.

We do know this—that we did become overstocked, inflated in all ways, and that we did fall into the doldrums. We do know that business has shrunk to a point where it is trying men's souls, and that recovery to anything like a workable plane will probably be a matter of some time. Note the use of the words "workable plane" instead of "normal." For when quite a number of industries are anywhere from 25 to 400 per cent overequipped as to actual necessary capacity, what may "normal" be? This question alone is an all-absorbing one in many if not in the majority of industries.

When the recovery of the business patient starts to gain headway, what will happen? Will each individual unit of each major industry engage in a wild scramble for the slowly increasing business? Will such a scramble result in better prices, or in prices which will reflect the scramble? Will the units comprising any one industry cooperate to stabilize that industry and its relation to other and competing industries—or will they think only of themselves and forget that they are each but a single unit of some one industry whose very existence demands a solidarity of its component units?

When, in the quite distant future, business is again sailing comparatively smooth waters, will industries as a whole and the units which compose them forget the rough waters of 1930 and 1931? Will they build and build and build—irrespective of obvious capacity? Will they accumulate large inventories—too large even for good servicing of customers, and then drive their sales forces to sell the goods without any thought except the slogan of *volume?* And will they each advertise enough to sell the entire output of the industry to help out in the wild scramble to get the business?

Then, as business becomes brisk, when the rough waters have been entirely forgotten, will every one begin again to think in terms of great magnitude, mergers, high stock values, and again set the scene for another grand smash?

Who can answer all these questions? Management—and no one else. Management as a class; management as an industrial group; management as a unit of an industry; management as expressed in terms of department heads, branch sales managers, foremen of plant departments, and so on down to the lowest individual responsibility.

Therefore the scope of management in our future business development seems to be boundless. It seems, in fact, to compass all that may be regarded as the hope for the future stability of business—not just high-profit producing, but a real, solid, stable, and permanent business structure.

The management which will contribute to our future business development must be of the type which furnishes true leadership. It must be of the type which submerges individuality in the building of a broad managerial spirit throughout the entire organization. It must be of the type which instils a sense of responsibility into every key man in the organization, thereby taking into the so-called management function every individual who has under his control subordinates who must perform creditably.

Therefore, as we consider the scope of management in our future business development, we must take into account—

1 What *is* good management?

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[1] Partner, Stevenson, Jordan & Harrison, Management Engineers.

Presented at a meeting of the Metropolitan Section of the A.S.M.E., New York, February 6, 1931. Abridged.

2 What is the real duty of management in each individual company?

3 What is the real duty of the management of each company in respect to the industry of which each company is a part?

I—WHAT IS GOOD MANAGEMENT?

We have already touched on some phases of what constitutes good management. But we may go a little further, and mention five very important factors in the psychological set-up of an organization which is well managed.

First, the executive management itself, the big men at the top, will be real leaders. They will so visualize their jobs that no thought of personal detailed accomplishment will exist, much less be proclaimed.

If we abide by the example set by the management of most successful companies, we must conclude that "management" must mean the type of true leadership, serving subordinates with advice, counsel, and backing, building subordinates into strong and virile men, thereby broadening the executive force to reach down and throughout the whole organization.

Second, no real leader will fail to arrange his organization procedure so that every one knows his job and the job of every one else. Such setting up of organized procedure may be formal or informal.

But size of company regulates the degree to which an unrecorded or uncharted organization set-up may prevail. It is not possible for the chief executive or executives to pass along their ideas of scopes of responsibility and authority to the many subordinates in every department. Therefore it becomes necessary to have charts and manuals of responsibility to guide the many individuals who are not close to the top executives.

In any event, whether by understanding or more formal means, there should be a clean-cut understanding of scopes of responsibility and authority, thereby creating the means for management to broaden itself safely, understandingly, and effectively. It is only by such means that a true leader can express himself in organized terms. Of course he will still lead and act. But this will be through a scheme which will project his leadership, his principles, his ideals, and his managing ability much further down the organization than would be possible by any other means.

Third, every group responsibility, major and minor, should be backed up by records. It would be useless to hope for real progress without an accurate knowledge as to results. This point is too obvious for further discussion.

Fourth, records alone, giving comparisons with past performances, are inadequate. In these days of rapid progress it is not enough to compare with "same period last year" or even sometimes last month. Standards of what should or must be done must be set up, and actual performances should be compared with these standards rather than—or at least in addition to—past performances. This term "standards" is an all-inclusive one for our discussion. It includes budgets of expenses in all departments, standard costs of goods, quotas of production, quotas of sales, and all such.

Fifth, fixing a responsibility alone is a powerful incentive. Every red-blooded individual likes to have a job put up to him squarely. But sooner or later, when great effort is expended with successful results, when a few who expend super effort produce results obviously better than others, a new element of management mechanism—incentives—becomes necessary. And why should this not be so? Whenever a department or division thereof lends itself to being measured as to results, and where such a measurement may assure to the company a proper return for the normal salaries paid, is it not a logical action to set up a plan whereby savings made by super effort will be shared with those who were instrumental in making them?

Therefore the setting up of incentive plans intimately tied in with responsibilities completes an executive picture of tremendous psychological power.

First and foremost, therefore, good management involves proper leadership. We must then have a clean-cut organization, thoroughly backed up with records. To make more effective all operations we must have within these records a complete set-up of what *should* be done—that is, standards of performance. Finally, we should have an effective plan which makes partners of every one by sharing with each key man the savings made by bettering a standard which in itself is as good a performance as might be expected from any normal group or individual.

II—WHAT IS THE REAL DUTY OF MANAGEMENT IN EACH INDIVIDUAL COMPANY?

First, a real duty of the management of each company is to develop a stable and permanent business.

Not long ago the author had a rather intimate contact from an observer's standpoint with the absorption of a large company by another one not much, if any, larger. The absorbed company, which we shall call company A, had developed a magnificent business in special brands of food products. It had spent hundreds of thousands of dollars in research, had slowly and painfully at times built up a big business. It held its business and gained new business by sheer force of good goods, well made, well protected by scientific research and operating checks, and well sold.

There was a flurry on the stock market, and up went the stock of company A, well over 100 per cent. Soon it was announced that company A was controlled by company B. Now, company B was not in the food business. It was controlled by people who expressed their belief in business as follows: Buy companies with established brands, and buy only the brands. Eliminate all research work, betterment of already good products, and similar activities, discharge all the key employees of the bought company, pare the expense of operation down to the core, and "cash in."

It seems entirely hopeless that such a company can last or hope to be a stable, solid, and permanent institution.

So, the making of flash-in-the-pan profits is about the last *real* duty of the management of an individual company, especially when such a company is owned by the public through its listing on a regular stock exchange. By positive reasoning, the longer route of safe and sure building for permanency is the prime duty of management to each individual company, and certainly as well to the personnel which makes up the organization of each company.

Second, another real duty of the management of each company is to cause not only the company but also its personnel to become identified with the social and community life of the cities, towns, and villages where its activities are located. Certainly a niggardly and non-cooperative attitude toward public responsibilities can result in nothing but a niggardly and non-cooperative attitude within the organization itself. And from a selfish standpoint, this is bad business.

In large cities especially, we see political activities dominated by political machines. This is but a natural result in great centers of population, but its extent would doubtless be less if the management of business concerns would themselves lead their subordinates in taking a more active part in public affairs. Can it be that neglect of management in such matters may account largely for our political and racket conditions?

III—WHAT IS THE REAL DUTY OF THE MANAGEMENT OF EACH COMPANY IN RESPECT TO THE INDUSTRY OF WHICH EACH COMPANY IS A PART?

We find countless examples of managements which, in their own organizations, are fair, impartial, and perfectly straightforward, but when pitted against other companies in meetings dealing with the interests of the industry as a whole prove anywhere from evasive to positively crooked.

Today is a day of competition, just as much between industries as between individual companies in the same industry. Buying on the instalment plan mortgages income to pay for automobiles or radios, for instance, in which case wearing apparel, house painting, etc. are losers. Brick in fancy styles fights weathered shingles or stucco for residences. Concrete fights steel. Rubber floor covering fights cork. Steel office furniture fights wood. Tile or asbestos roof coverings fight wood shingles or slate.

When business slacks off, the management of each individual company in any industry is confronted with a real test. Shall selfish interest in its own company predominate, or shall activities be kept parallel to the state of the industry? In an attempt to maintain volume, will the management of a company cut prices, give secret rebates, give long credits, and employ all the other artful devices, or will it stand pat with the other companies of the industry?

In 1927, the author's partner, Mr. Stevenson, conducted a research into the question of whether or not it ever paid to take business at or below normal cost. Nearly 700 companies contributed their answers to a number of questions, one of which was, "Do you believe that you can take business at or below normal cost without affecting adversely the industry of which you are a part?" The answers were as follows:

		Per cent
Qualified yes	22	3
Yes	43	6
Qualified no	17	3
No	593	85
No reply	21	3
Total returns	696	100

Together with these answers came many objections of the most positive kind against taking business at prices which would be based on costs lower than those when the plant was running at normal capacity. And it might be added that "normal" is not full-speed operation, but operation at a basic volume representing a true picture of what experience and past history, together with present conditions and future expectations, would indicate as the volume to be expected year in and year out.

Supposing the total capacity of an industry is ten billion units of something. Ten companies are involved to the extent of 95 per cent of the industry. Let us assume that two companies have a capacity for two billion units each, making a total of four billion or 40 per cent of the industry. Four companies have a capacity of a half-billion each, and four a capacity of a quarter-billion each.

Business in this line, as shown by the statistical chart of the group, is normally, year in and year out, 70 per cent of the entire capacity or 7 billion units. Note that there is 30 per cent *overcapacity* on normal running.

Then business slowly recedes until there is only enough to occupy 35 per cent of the total capacity—or, expressing it differently, 50 per cent of the normal volume. These are figures which are not far from the actual circumstances for many industries today.

What, now, is the real duty of the management of each of these companies? Size alone does not always mean lowest normal cost. Often it may be found that one of these quarter- or half-billion unit plants can produce at lowest cost. So, what is going to happen?

One company says that it must maintain a volume of 50 per cent of its capacity and proceeds to do so. As the industry as a whole is only on a 35 per cent basis, this means taking customers from some one else. This particular some one naturally objects, and a useless, futile, senseless, and ruinous war is on.

What, then, is the real duty of the management of individual companies in respect to the industry of which each company is a part? Would it not seem quite obvious that it lies along the lines of cooperation with the industry—not to fix prices or gouge the public, but rather to recognize the condition of the industry in its various surges of volume and to adjust the operations of each company to the conditions as indicated by the statistics of the industry? In the great majority of cases, when one or two companies endeavor to get all the business the net result is disaster to themselves and the whole industry.

In addition to this matter of getting business in dull times, with its attendant disastrous results, there is another and most important feature of the relationship of individual companies with the industries of which they are a part. This is the cooperation necessary by each company in all constructive moves designed to upbuild the industry. It includes, among other things, group research, advertising, and promotion of the products of the industry. Research includes all such things as betterment of products; new uses for products; the promotion of uses of products as against competing products; the improvement of processes in order that the products of the industry may better compete with opposing products, and all such matters vital to the industry as a whole.

Responsibility of Management as to Plans for Future Volume

One of the greatest problems of management in our future development is that of correctly appraising the volume of business which will be available. Many factors enter into this problem, and it is not within the scope of the present paper to offer any tangible conclusions. It may be well, however, to call attention to many indications which point to a very serious curtailment or perhaps even an almost complete cessation of export business, which business has in the past occupied a considerable portion of our productive facilities. Some things which management must consider as to their effect on export volume are:

1 Our own tariff policies and their effect on foreign countries.

2 Developments in Russia.

3 Developments which might at no far distant day take place in India.

4 Developments in all countries where labor rates are such that, given the plants and products to do business, we, with our high labor rates, will be out of the running. Plants are being built all over the world by foreign and American capital to make products of American design and development, which cuts into our export business heavily.

5 Instalment buying contributed its share to a peak volume of business, which apparently must be discounted in the calculation of future "normal" levels.

6 Paper profits on stock speculations stimulated volume of purchases—even of homes and other commendable items—most of which disappeared when the market broke, leaving a trail of struggling debtors trying now to pay up for over-extended purchases. Such stimulated volume must be discounted in our future calculations.

Management's Job in the Internal Organization of Individual Companies for Future Development

The management of each individual company has a very important job on its hands in the tuning up of its organization to produce the maximum results for the minimum cost.

To illustrate, and to bring out a few points on this important subject of broadening and perfecting management, let us consider four of the main functions of doing business, namely,

Engineering (Design of Product)
Manufacturing
Selling, and
Accounting.

Engineering. To keep any place at all in its field a company must maintain a line of products thoroughly up to date, and at a reasonable price. It is at this point where the engineer comes most prominently into the picture.

Three things enter into this function of "engineering" the products of a company.

1 The products must be adequate to fulfil the requirements of the sales department for maintaining a proper sales volume from the standpoint of design and effectiveness.

2 The products—acceptable to the customers from a design standpoint—must be so designed that they may be manufactured at a cost which will permit their sale—and the wider the margin of profit the better.

3 The products must be backed up by the engineers themselves in the field when occasion demands.

Management in its best and most effective form requires, therefore, that the engineering function be tied very closely with sales and manufacturing. Engineers deeply engrossed in pure research have their invaluable function when a company is large enough to maintain such research or when an industry as a whole may so do. But in our future development, that portion of the engineering profession which is responsible for what has just been described must broaden its mental scope to include a vision of field requirements of a practical nature, manufacturing requirements whereby products may be produced at a cost to permit both the securing of business and the making of a profit, and accounting requirements whereby the engineer may have a fuller understanding of what everything means as expressed in figures.

Manufacturing. Given products to turn out, given a schedule by the sales department on which to work, the manufacturing department is then responsible for producing goods at a cost which will permit enough trading margin to assure a profit to the company.

Taking industry as a whole, there are undoubtedly more management problems in the manufacturing department than in any other. There are many more employees involved than is usually the case in all the other departments put together Therefore it is but natural that management has paid much more attention to the manufacturing department than to others.

In these days of highly specialized mechanical devices, when labor-saving machines have been installed to speed up production and reduce labor cost, is there not a possibility that our minds have become too deeply engrossed with such mechanization, with a resultant disregard or neglect of what might be termed the human side, at least to the point of trying to figure out where supermechanization will lead us in the future?

In his experience the author runs into two very separate and distinct schools of management in connection with the discussion of key men and executive incentive methods.

One school can see that the setting up of an incentive method where each distinct division of the plant may run on its own basis, thereby establishing, as it were, a little separate and distinct business, is a plan that brings out more initiative than any other can possibly do; that is, this particular school is of the type that prefers to lead rather than drive. It prefers to institute schemes that will bring the very best out of every superintendent, foreman, and assistant foreman in the entire organization. In other words, this school believes in broadened management, and such higher executives are finding in the long run that to broaden their management control in this manner is a very profitable procedure.

The other school consists of executives who are perfectly agreeable, say, to having the departments set up budgets, but they prefer to use these figures more for the purpose of finding out what is going on, and with this knowledge to specify what these various department heads shall do and shall not do.

In other companies where incentive methods of the "savings" type have been set up, it has been observed that a number of executives who, in the performance of their duties, have sat down with department heads to discuss with them retrenchment programs, have mistaken their jobs to such an extent that they have made the statement that these cuts of expenses would have taken place whether or not a bonus plan was in existence. To the author, such a position is quite untenable, as whenever a bonus plan is in operation it eliminates the resistance of superintendents, foremen, and assistant foremen to cutting down expenses which in the past they would have resolutely stood for under the plea of preserving organization.

After all, does not the management of a manufacturing department come right back to the same problems that hold throughout business in general? Driving as such is a thing of the past. The management of the future, particularly in all the multitudinous details of the manufacturing department, must broaden itself by making every individual who is responsible for a group of other individuals an executive in fact, thereby creating many eagle eyes throughout the entire organization, and obtaining in consequence decreased costs as well as a greater speed of quality production.

Selling. It seems to the author that the greatest field of management in all future development is in the function of selling, and, when the word "selling" is used here, let it be in an all-inclusive sense, which may perhaps better be described by the word "distribution." The sales department of any business is, to a great extent, the one which must through necessity sense the requirements of the consuming public, both as to nature of goods and as to volume. It is largely from information gleaned by the sales department that a business regulates its designing, the nature of the goods it sells, and all the other important considerations which govern the operation of the business.

The sales department must perform market research. It should be constantly on the lookout for new uses for the products manufactured by the company. It should be constantly alert to learn how existing products can be bettered, and pass its information along to the engineering department. It is up to the sales department to skilfully maintain service to customers, not only from the standpoint of servicing goods sold, but also from that of deliveries whereby customers may be served with goods at the time and at the place desired.

A very decided function of the sales department is that of constantly broadening its scope as to the coverage of customers, the development of new territories, and all matters related thereto.

Publicity for the company itself and for its products must be maintained to an effective degree through advertising.

During all the time that manufacturing departments have been subjected to almost every conceivable kind of management mechanization—and by this is meant incentive and other such control methods—the sales department has been allowed to run pretty much on its own basis, depending very largely on the personalities of those involved with the selling function, and in many cases it has been found out too late that many of these personalities work altogether too much on impulse, with the result that a lack of systematic planning has created a selling structure which has become top-heavy and ineffective.

In our future business development it will undoubtedly develop that the heads of our large selling organizations will be more of the broad executive type than of the "star-salesman" type. Even the heads of large district offices, where they may be responsible for a considerable number of salesmen, will also be more of the executive type than of the star-salesman type.

Management in the past has made more or less sporadic attempts to provide sales departments with incentive methods. The great objection to the carrying out of an incentive plan for each individual salesman as a management function is the difficulty in maintaining territories and of giving proper credits for sales. Another serious one is that many times a salesman of high quality may not get along amicably with some of his customers. In such cases, another salesman may very profitably take over and relieve the situation. Sickness occurs, and another salesmen is obliged to cover the territory of the one who is sick. Further, salesmen differ in their temperaments and in their inclinations toward the various products manufactured by the company. This means that some salesman may often profitably go to a customer of another salesman and effect a sale which might otherwise never be consummated.

The reason that no greater progress has been made in putting sales departments under budget and quota controls more nearly comparable to those of manufacturing departments, has been that sales departments

have not considered themselves amenable to such devices. When a sales department is asked to set for itself a quota of sales, the statement has too often been made: "How can we tell what we shall sell?" That is exactly what they must tell, and that is exactly what they can tell if they will perfect themselves in their knowledge of field operations and field conditions.

Accounting. Up to the time when income taxes were first imposed in this country, accounting departments of companies were looked on very largely as nothing but a necessary evil. However, income taxes soon convinced management that it had to know more about its business, otherwise taxes would be paid which should not be.

Within the last ten years, tremendous advances have been made in the nature and valuable applications of accounting data. In fact, the designation "accounting" has, in a measure, outgrown itself, particularly when one considers that it no longer applies purely and simply to a statement of profit and loss, together with schedules of balance sheet, surplus account, etc.

The development of standard costs has been very rapid during the past decade. Standard costs may be quickly described as statements of what things ought to cost under normal circumstances. Such costs are indeed very different from what things actually do cost. Therefore management has had quite a problem in convincing itself that standard costs are of real value and are *the* costs on which a business must regulate its actions.

The difference between standard costs and actual costs which do not measure up to the standard costs is usually attributable to inefficiency. Standard costs, being built up through studies of every operation, become the par which must not be exceeded if the business is to make a good profit.

It is logical, therefore, that these standard costs have become the basis of incentive methods whereby a percentage of the savings made by beating the standards is turned into a bonus fund for distribution among those who are responsible for having made the savings.

While it is true that many of the functions in connection with standard costs and related control figures are in reality functions of the manufacturing department, they must at the same time coordinate accurately with the general accounts of the company. It is for this reason, therefore, that management has, in progressive companies, recognized the great value of the new type of accounting and of the setting of these standards which in themselves become an invaluable control for the business.

Back in 1903 the author was advised by a well-known engineer to take up the active study of cost work on the basis of the prophecy made by the latter at that time, which was: "Engineering costs will some time be the controlling factor in industry." It was this advice which then started the author out in professional practice, and in the twenty-eight years of development since that time we have almost come to a complete fulfilment of the prophecy made by this engineer.

More and more management is relying not only upon proper records of achievement, but even to a greater extent on the records which show what should be achieved. Comparisons with past effort are often most dangerous. We may be comparing with accomplishments which are so far under par that any such comparison would be most detrimental. While we may compare with past effort purely from the standpoint of curiosity, our real comparisons must be with what *should* be accomplished rather than what has been accomplished.

The scope of management in our future business development, therefore, will most certainly include a greater reliance on the new type of accounting as it is rapidly being developed at the present day. No management can hope to succeed to any degree unless it has a definite and trustworthy means of measuring every function of its business.

Machinability and Wear Resistance of Cast Iron

TWO properties which are at present engaging the attention of engineers, particularly automobile engineers, are machinability and wear resistance.

Machinability is measured by a drill test, in which the depth of penetration of a standard drill is measured after 50 revolutions at a standard cutting speed and standard pressure. For testing machinability, however, German experimenters are rapidly abandoning the drill test in favor of a cutting test over a period of 20 min. to 1 hour, in which the test piece is machined in a lathe at different cutting speeds, rates of feed, depth of cut, etc. The time taken to dull the standard tool is taken as a measure of the machinability.

For measuring wear resistance a dry rolling-friction test was used in which a small roller of the iron to be tested was pressed at constant pressure against a rotating cast-iron shaft. The loss of weight after 30,000 rotations—equivalent to 32 miles—was taken as a measure of wear resistance. The materials tested were mostly cylinder irons with and without nickel additions. There appeared to be no connection between machinability and wear. Nickel gave a greater uniformity between the various irons because of more uniform graphite distribution. The variations in wear were mostly accounted for by structural differences, especially in graphite size and arrangement. It was found that small "clean" graphite flakes generally gave the best wear results. Phosphorus appeared to give decreased wear resistance, although exceptions were encountered. A cylinder iron containing about 1.5 per cent silicon and 0.8 per cent nickel with 0.5 per cent phosphorus gave good wear resistance, reasonable machinability, and a good degree of uniformity between different castings made to the same approximate analysis. Heat treatment offers the alternatives of a good wearing but unmachinable iron, or a soft machinable iron with poor wearing qualities.—*The Metallurgist* (Supplement to *The Engineer*), May 29, 1931, p. 80.

Survey of Engineering Progress

A Review of Attainment in Mechanical Engineering and Related Fields

Post-War Land-Turbine Development

A British Point of View

WHEN the European war broke out, the electrical power industry was on the eve of great developments. The manufacturers of turbine machinery, on whom the industry relies so largely for its progress and even for its existence, were preparing to supply it with generating plant far in advance of anything that had gone before. It may be said that development had indeed commenced in 1912 with the construction, at Newcastle-on-Tyne, of a notable unit of 25,000 kw. This machine, which passed all previous records for size and efficiency, probably represented the high-water mark of turbine construction prior to the war. The set, it may be remarked, is still in service at the Fisk Street station, Chicago.

During the years that the war was in progress, new development received a check, though two important steps forward during the war years have to be recorded. First came the raising of total steam temperatures and pressure when the Carville "B" station was put into service in 1917; the machines at this station represented a very large increase in output compared with previous practice at 2400 r.p.m. Later came the North Tees "A" station with turbines working at a pressure of 450 lb. per sq. in. and the adoption of the resuperheating cycle.

During the period with which the paper deals it will be seen that the maximum size of units built by that company has increased from 60,000 kw. to 160,000 kw., pressures have gone up from about 200 lb. to 1300 lb. per sq. in., temperatures from 600 deg. to 800 deg. fahr., and available heat from about 400 B.t.u. to well over 500 B.t.u. per lb.

Improvements in Efficiency

Turbine Efficiency Ratio. The improvements in turbine internal efficiency, as distinct from gains due to a greater temperature range, are particularly noticeable when considering the smaller sizes of plant. From curves in the original paper it appears that although the efficiency ratio of a 25,000-kw. turbine has increased by 4 per cent since 1913, the improvement in a 3000-kw. set has been nearly 13 per cent, and a modern 3000-kw. turbine is only 5 per cent less efficient in steam consumption than the present-day 25,000-kw. machine. A bigger difference would be found, however, in comparing heat consumptions since the larger unit would permit the use of a more comprehensive feed-heating equipment. Improved designs in nozzles and blading and the use of higher velocity ratios have been mainly responsible for this increase of efficiency.

The author calls attention to the improvements that permitted these results and also to the use of moderate steam-jet velocities as a means of obtaining the highest efficiency in a steam turbine. This is done by the adoption of multi-stage design with a small pressure drop per stage.

Thermodynamic Cycle Efficiency. A large table in the original paper which cannot be reproduced because of lack of space, together with curves, shows the general range of initial pressure, heat drop available, and heat consumption generated for representative Parsons machines. The heat drop may be increased by raising the steam pressure, raising steam temperature, reducing back pressure, and understage reheating and pressure expansion. All of these methods are discussed in some detail. The author believes that turbine design for the present will probably stabilize itself at a maximum temperature of 850 deg. fahr. until metallurgists produce an alloy steel or other material at a price enabling the temperature to be economically raised.

The British Thomson-Houston Company have built for the Detroit Edison Co. a 10,000-kw. tandem two-cylinder machine to operate at an initial temperature of 1000 deg. fahr. with a stop-valve pressure of 365 lb. per sq. in., and much valuable data will be obtained from the plant after prolonged operation. The same gain in the thermal efficiency would have been realized had the initial pressure been raised from 365 lb. per sq. in. to about 1000 lb. per sq. in. and the temperature limited to 750 deg. fahr., but difficulties due to wetness at the exhaust end would have been introduced. Experiments carried out at Messrs. Parson's Heaton Works with ordinary mild-steel superheater tubes showed that these were quite unsuitable for a total steam temperature of 950 deg. fahr. at a pressure of 200 lb. per sq. in., but it was realized that the independently fired superheater used was being forced to obtain that steam temperature and the outer surface of the tube probably reached a temperature of 1300 deg. fahr. or over. On the other hand, it was not overlooked that with steam at higher pressures, the increased density would enable a lower external tube temperature to be maintained.

A decision as to whether the back pressure may be reduced in any particular case is purely one of economics, and circumstances seldom justify a back pressure lower than 1 in. of mercury absolute. An extension of the thermodynamic cycle made possible by the adoption of reheating depends upon whether the reheating is carried out by flue gas or live steam. Reheating by means of flue gases was adopted in two British stations. The only trouble is that it takes a longer time to reach steady conditions when starting up, which makes the method suitable for a base-load machine. Some minor troubles were experienced, but so far as the turbine is concerned, the anticipated reduction in heat consumption has been obtained.

The practice of reheating by means of live steam has been tried in certain cases, but generally where the initial steam pressure has been comparatively moderate. With a constant total temperature, the higher the initial pressure the greater is the advantage derived from reheating, and where the steam pressures are relatively low the thermal gain due to reheating has rarely justified its adoption. For initial steam conditions of 600 lb. per sq. in., and 800 deg. fahr. total temperature, reheating can be justified for large units, while for 1200 lb. per sq. in. initial pressure and the same temperature, reheating is easily justified thermodynamically and is practically a necessity from an erosion and

final-stage-efficiency point of view. Extended experience in the United States has been so varied that it is difficult to draw any very definite conclusions as to the trend of opinion there. Several of the earlier reheating installations utilized flue-gas reheating, while later, live-steam reheating was adopted, but at the present time it would seem that a return to flue-gas reheating is being made.

At the Dunston plant reheating will be by flue gas, the reheater element being located in a combined reheat, normal-evaporation boiler. Flue-gas reheating is essentially a boiler problem since it does not add appreciably to the turbine design, although it may necessitate changing from two- to three-cylinder machines in very large outputs.

The tendency during the past decade has been to raise both the steam pressure and temperature without the general adoption of interstage reheating. The back pressure has remained sensibly constant. The future development will probably be along the lines of a still further increase of the steam pressure without a larger increase in the steam temperature, but with the adoption of interstage reheating. This, of course, applies to the large units which are not commonly regarded as being the size of machine to be adopted for modern power generation.

Increase in Unit Size

50,000-kw. sets at 3000 r.p.m. are under construction on the European continent, and sets up to 80,000 kw. at this speed are contemplated. Blade-tip speeds have increased from 700 ft. per sec. to an average figure today of 1000 ft. per sec., and even 1150 ft. per sec. Longer blades will probably be used in the future.

Consideration has been given to the possibility of a 90,000-kw. single-flow machine at 1800 r.p.m., equipped with blades 40 in. long in the final row, with a tip speed of 1257 ft. per sec. Messrs. Brown, Boveri also report the use of a maximum tip speed of 1140 ft. per sec. Recently Dr. Melan of the Siemens-Schuckert Werke, Berlin, stated that his company can build a single-cylinder turbine of 90,000 kw. capacity at 1500 r.p.m. without exceeding the ordinary factors of safety, by the use of a specially constructed rotor in which the low-pressure disks have no central holes but are bolted together longitudinally. This construction is not new, having been proposed by Dr. Roeder in 1915. The use of a wheel without a central hole was first adopted by De Laval in 1896 for the larger units of his well-known simple impulse turbines.

Limiting Factors in Size Development

In dealing with this question the author considers only 3000-r.p.m. machines, since 50-cycle supply is becoming standard in Europe. The first limit to turbine size is the alternator, as few manufacturers are prepared to build alternators with an output exceeding 60,000 kw. at 3000 r.p.m.; although a combination of a multi-cylinder turbine and tandem alternators could readily give an output of 120,000 kw. at 3000 r.p.m.

Modern standards of efficiency in this country demand a leaving loss at most economical load not exceeding, say, 3 per cent, while financial considerations seldom allow it to be less than 1 per cent. American practice allows a leaving loss up to 5 or even 6 per cent at economical load, thus enabling much bigger outputs for a given stress to be obtained, but at a lower efficiency.

The area available for a single exhaust is largely limited by the blade-tip speed to which the designer is prepared to go, and by using high-grade alloy steels for disks and blades, higher stresses can be safely used, and blade-tip speeds of 1200 ft. per sec. should be quite safe. The maximum single-exhaust annulus area known to the author for a 3000-r.p.m. machine is 22 sq. ft., and for an absolute back-pressure equivalent to 1 in. of mercury with a leaving loss of 2 per cent, this gives an output of 12,000 kw. per exhaust, when no regenerative feed heating is adopted. Tandem cylinder turbines with a double-flow low-pressure cylinder are very common, and form one method of obtaining increased output. Three-exhaust two-cylinder machines offer another solution and make a 50,000-kw. (maximum continuous rating) 3000-r.p.m. machine of reasonable length fairly simple. Further multiplication of exhausts, however, is costly and, in general, not warranted.

Erosion. This is a very serious problem as a machine operating at an initial pressure of 450 lb. per sq. in. with a total steam temperature of 750 deg. fahr. and exhausting at a vacuum of 29 in. of mercury, will have approximately 10 per cent of the total fluid passing through the last row in the form of water, unless reheating or some form of draining is adopted. Erosion is affected by blade-tip speed, absolute back pressure, presence of air or other non-condensable vapor, wetness factor of steam, and form of blade and blade materials. Other factors being constant, the lower the back pressure the greater the effect of erosion, since the cushioning action of high vacua is less pronounced. Erosion increases very rapidly with increase of blade speed, and while the

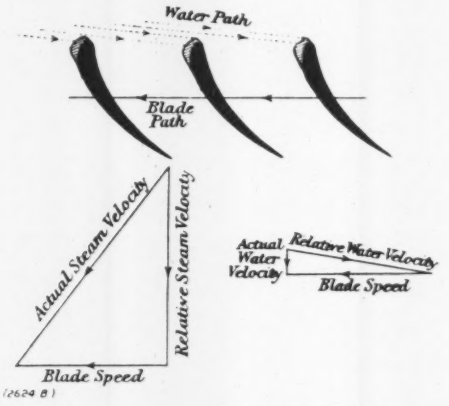

FIG. 1 SHAPE OF LEADING EDGE OF REACTION BLADE AT EXHAUST END

tip speed 800 ft. per sec. may not call for any special precautions, on reaching 1000 ft. per sec. a drastic remedy is demanded. The final solution of the problem of erosion will probably be a combination of draining and erosion-resisting blading. The larger water particles do not follow the steam path, but tend to be thrown to the outer circumference of the steam annulus, thus assisting the draining problem, but that draining cannot be completely successful is shown by the fact that the maximum erosion attack does not necessarily occur at the blade tip but roughly at from $\frac{1}{2}$ in. to 2 in. down from the tip. The author has not heard of a complete explanation of this, but it would seem to depend on the upstream steam path. Owing to their much lower velocity, the water particles concentrate ahead of the moving blades, and the resulting globules of water are hit by the blades at high relative velocity.

The problem of blade erosion is equally troublesome to both impulse- and reaction-turbine designers, and although in general the visible effect of erosion is rather less in the case of the impulse machine, the effect on efficiency is very much greater. In fact, as erosion only attacks the leading or entering edge of the blade, efficiency is unaffected in the reaction turbine since the blade efficiency is determined by the leaving edge, and it is only when the blade strength is seriously impaired that renewals need be considered. On the other hand, the shape of the impulse blade at entry is such that the water particles meet the blade on a surface approximately at 45 deg. to the water path, while in the

normal reaction shape the water particle strikes a plane normal to the water path, with consequent increased erosion. The shape of a reaction-blade leading edge has little or no effect on the blading efficiency, and this allows the problem to be attacked in a very simple manner since the shape of entry can be varied within wide limits without affecting the efficiency.

The author's firm now adopts a special shape for the leading edge of their exhaust-end moving blades, and protect this edge with a renewable shield of specially resistant material. The shape of the leading edge is shown in Fig. 1, from which it will be seen that the water particles strike the blade on a plane approximately 45 deg. to the relative direction of movement. Extensive researches carried out at the works with which the author is connected, have shown that 18 per cent to 22 per cent tungsten tool steel is very resistant to erosion, but this material is wholly unsuitable for making the complete blade. For moderate blade speeds austenitic alloys such as "Hecla," "Staybrite," "Anka," etc., are quite satisfactory, and have been used in commercial machines with considerable success. Provision is also made for partial drainage ahead of the last stage, and it is believed that a solution to the erosion question is found in a combination of drainage, leading edge, blade shape, and renewable shield material. The preventive for erosion once having been found, blade speeds will probably increase, and this will entail the use of very high-grade alloy steels for the final moving blades and disks, while the turbine designer will look to the steel makers and forgemasters to accept even more stringent conditions than the already onerous specification with which they have now to comply.

MATERIALS OF CONSTRUCTION

This part will be comparatively briefly abstracted as it represents mainly British practice. When the forging reaches the turbine maker's works, tests are carried out on it in addition to previous tests by the maker of the forgings. The practice at Heaton Works is to overspeed the unbladed rough-machine shape or disk in a specially constructed chamber, the test speed generally being one-and-a-half times normal speed. In the case of disks, the overspeed is carried on until the eye of the disk actually opens out and takes a slight permanent set. This leaves the material at the inner bore in compression when the disk is stationary. Details of the overspeed test chamber used at Heaton Works are given in the original paper.

RELIABILITY AND OPERATION

Remarkable progress in the reliability of turbine plant has been made in the period under review, and is particularly noticeable in the case of English manufacturers. The tendency both in America and on the Continent has been to increase initial pressures and temperatures rather more rapidly than in Great Britain. Increasing the output per exhaust with a consequent increase of blade-tip speed has, however, produced unforeseen vibration troubles in certain instances, and the engineers of several plants of large output in the U.S.A. have been forced temporarily to remove the final row of blades until a satisfactory solution is obtained. Progress is made by surmounting the difficulties encountered, but recent experiences seem to justify the rather more conservative policy adopted by English designers.

Blade Failures. Laboratory research has been done on the subject of disk vibration without completely solving it. The associated problem of blade vibration is still giving trouble. In 1929, 40,000 kw. of blading failures were recorded, but out of a total amount of plants ten years old or less in service the total failures during 1929 amount to less than 1 per cent, comprised of two machines. During 1930 the only failure was a 4000-kw. machine, and it was definitely traced to persistent boiler priming, while in 1928 not a single blading failure of any kind occurred.

Some Causes of Vibration. With increase of turbine output, steam pipes become both larger and stiffer. Several instances of very severe vibration being set up due to steam-pipe expansion troubles have occurred. A way suggested by the author to deal with this condition is to complete the steam range to the stop valve, providing distance pieces (say, 2 in. thick) in the three planes which need adjustment. The stop valve is then removed from the turbine and a blank flange fitted to the end of the steam pipe with a large-bore drain blowing to atmosphere. Trammels are made with the steam pipe cold, and steam is then turned on to the range and the drain at the end of the pipe allowed to blow until the temperature of the pipe rises to its full extent. The amount of movement from the cold to the hot condition is then measured by the trammels, but the distance pieces in the steam range are adjusted to insure that no forces are applied to the steam chest when the steam range is at full temperature. With very large machines, designed for high pressures, however, occasional instances of vibration have been reported, and where a steam chest is employed it is excellent practice to anchor it securely, and to provide flexible U-pipes between the steam chest and turbine cylinder. The steam chest is set in position so that forces from the pipe between steam chest and cylinder cannot affect the turbine cylinder. The main steam range is tested for expansion as described above, although, of course, in the case where the steam chest is securely anchored, elimination of steam-pipe forces is not so vital.

An interesting cause of vibration which was found on some of the first machines to employ total steam temperatures in excess of 700 deg. fahr. was the lifting of "dummy strip," which had been put in in lengths of 4 to 5 in. Due to the small section of the dummy strip, and the fact that at that time it was made of 70/30 brass, the dummy strip reached steam temperature very much more rapidly than the steel casting into which it was fixed, and owing to the differences in expansion coefficients the strip was subjected to considerable stress while it was at steam temperature. The rapid increase in length of the dummy strip during starting periods caused it to lift out of the groove and to come in contact with the shaft, thus causing vibration, while, in addition, the 70/30 brass rapidly disintegrated and became very friable, due, it is thought, to being heated while under stress. The complete cure of this trouble was obtained by inserting the dummy strips in lengths not greater than 1 in., and by making no attempt to butt the pieces accurately against each other, so that they were able to expand into the small gaps left between them, and thus did not rise, nor were they stressed to an extent which produced disintegration. With the advent of still higher temperatures however, it has been found advisable to use a more suitable material; manganese-copper is satisfactory up to, say, 725 deg. fahr., and a cupro-nickel alloy of the Monel or similar class for a temperature of 800 deg. fahr.

Among other cases of vibration are mentioned cylinder distortion as well as difficulty occasionally experienced when the machine is started some hours after it has ceased to carry load and before it is cool. Vibration due to this cause may be eliminated by turning the shaft through 180 deg. at regular intervals, say every hour, thus preventing the distortion; or its effect may be reduced by starting the turbine on a very low vacuum, thus passing a larger quantity of steam at a much greater density along the back end. Most very large machines today are fitted with some form of turning gear which is either of the intermittent or of the continuous turning type.

The provision of a turning gear is one which requires considerable thought, since if it is of the continuous type it will be necessary to maintain a minimum surface speed on the journal in order to maintain a film of oil, and thus to keep the coefficient of friction within limits. For a 15-in.-diameter journal the mininum

speed is about 20 r.p.m., and a turning gear which is robust enough to start the turbine from rest will probably be from five to eight times too large once this minimum speed is reached and an efficient film of oil secured in the bearings. For a turning gear of the intermittent type a coefficient of friction of about 0.03 must be reckoned with when turning at a low speed. A 50,000-kw., 1500-r.p.m. turbo-alternator will probably require a torque equivalent to about 300 hp. applied to the turning gear to start it from rest. This power can be very considerably reduced by providing a system of pressure lubrication to the center of the bottom half-bearing, with sufficient pressure to lift the journal clear of the bearing and provide a film of oil. The necessary pressure of oil varies, of course, with each machine, but is generally between 600 and 1000 lb. per sq. in. Should provision for high-pressure oil be made, the coefficient of friction will be reduced to, say, 0.0035, and the power required for the intermittent turning of a 50,000-kw. set reduced to about 40 hp.

A rare but very interesting cause of vibration in a turbine is described by the author as being due to the release of internal forging stresses. He also describes a method of heating bolts electrically developed by his firm.

Possible Speed Rise of Reheat Turbines

The limitation of total steam temperature to something like 850 deg. fahr. makes reheating or resuperheating an absolute necessity if full advantage is to be taken of the increased pressures which are certain to be used in the future. This introduces a problem which is of considerable importance in the design of turbine plant, namely, the calculation of the rise in speed of the lower-pressure spindles due to the steam stored in the turbine, reheater, and interconnecting pipes. It is assumed that the load goes off the alternators, that the high-pressure emergency governor operates, but not the reheat pressure emergency valves and, thirdly, that the vacuum breaker fails to act, so that full vacuum is maintained on the system. A combination of circumstances such as this may not appear at first sight to be a likely one, but it should nevertheless be considered and a turbine design arranged accordingly. The matter is of greatest importance when the reheating is carried out by boiler flue gases, as distinct from steam reheating, for this involves the use of long pipes of large capacity running to and from the boiler room.

The author considers the problem as to what will be the maximum rise in speed and how long it will take to reach it under the circumstances outlined above so that the safety of the plant in the event of a possible accident may be judged.

The case taken is that of a three-cylinder machine in which reheating is carried out between the high-pressure-cylinder exhaust and the intermediate-pressure-cylinder inlet. In this case the volume of the steam is that in the high-pressure cylinder, in the pipe line from the high-pressure exhaust to the reheater, in the reheater itself, in the return pipe line to the intermediate-pressure cylinder, in the pipes from the intermediate-pressure to the low-pressure cylinder, and a portion of the steam in the low-pressure cylinder. If there are feedwater heaters supplied with heating steam from the intermediate-pressure and low-pressure turbines, these will form additional means of absorbing the steam remaining in the system, and the acceleration of the turbine will be correspondingly reduced. In the following outline of the method of calculation it will be assumed that there is no steam extraction.

The author arrives at the following expression:

$$N = \frac{30}{\pi}\sqrt{\omega_1^2 \frac{2E}{I}}$$

where N is the rotor speed, E is the energy input from the steam at any instant dt, so that $E = Pdt$, where P is the power input into the turbines and t is the time interval during which the stored steam is discharging into the intermediate- and low-pressure turbines. From this equation the curve of N on the basis of t can be plotted. The losses depend upon the speed N and are comparatively small.

It may be assumed arbitrarily that the alternators remain excited or not, and a curve of losses, including windage and bearing friction at any speed of rotation, may be obtained from the designers of the alternators. For the losses W in the turbine bearings, these may be taken as being equal to $KV^{1.5}$, where K is a

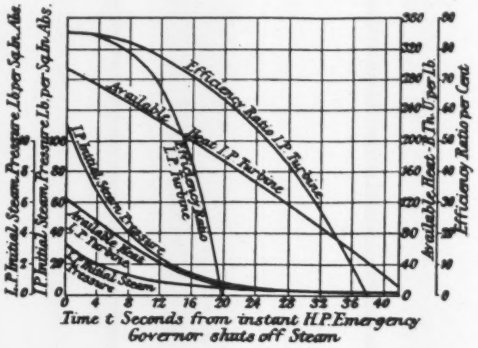
Efficiency Ratio I.P. Turbine
Available Heat I.P. Turbine
Time t Seconds from instant H.P. Emergency Governor shuts off Steam

FIG. 2 CURVES SHOWING CALCULATED EFFECT OF DISCHARGE OF REHEATER AND PIPES INTO H.P. AND L.P. TURBINES AFTER H.P. EMERGENCY GOVERNOR HAS SHUT OFF STEAM FROM BOILER—LARGE THREE-CYLINDER REACTION TURBINE WITH REHEATER

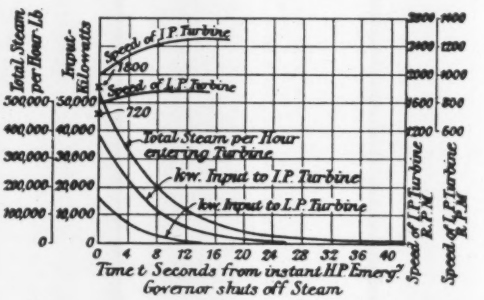
Speed of I.P. Turbine
1800
Speed of L.P. Turbine
720
Total Steam per Hour entering Turbine
kw. Input to I.P. Turbine
kw. Input to L.P. Turbine
Time t Seconds from instant H.P. Emerg. Governor shuts off Steam

FIG. 3 CURVES SHOWING CALCULATED EFFECT OF DISCHARGE OF REHEATER AND PIPES INTO H.P. AND L.P. TURBINES AFTER H.P. EMERGENCY GOVERNOR HAS SHUT OFF STEAM FROM BOILER—LARGE THREE-CYLINDER REACTION TURBINE WITH REHEATER
(Normal Turbine Speeds: H.P. and I.P., 1800 r.p.m.; L.P., 720 r.p.m. Tripping speed 10 per cent above normal.)

coefficient determined by experiment and V is the surface velocity. Curves for these losses can then be plotted on a base of time t and added together, giving the total losses L to be introduced into the equation above. In Figs. 2 and 3 the results of a typical calculation on these lines are shown in graphical form.

Governing

The modifications made to governing systems during the past ten years have been mainly in detail only. The increase of total steam has introduced some distortion difficulties in the neck glands of the governor valves, but this has been eliminated by the use of "Perlit" iron. One interesting advance recently made is the variable-level ratio system by which a straight-line governing characteristic (i.e., rotational speed plotted against load) is obtained. As to governing valves, simple valve shapes are desirable, and a double-plate valve offers the best solution. The steam-flow characteristic of this valve, therefore, is by no means a straight line. To obtain straight-line governing with a double-

plate valve the relation between valve lift and governing movement must be made similar to that between valve lift and the weight of steam passed. This can be done simply by the toggle mechanism shown in Fig. 4, from which it will be seen that as the governor valve opens the point *G* is moved closer to the relay plunger, thus increasing the lever ratio between governor and oil relay. The mechanism is so proportioned that straight-line governing is obtained.

The author describes next the use of a butterfly valve in the

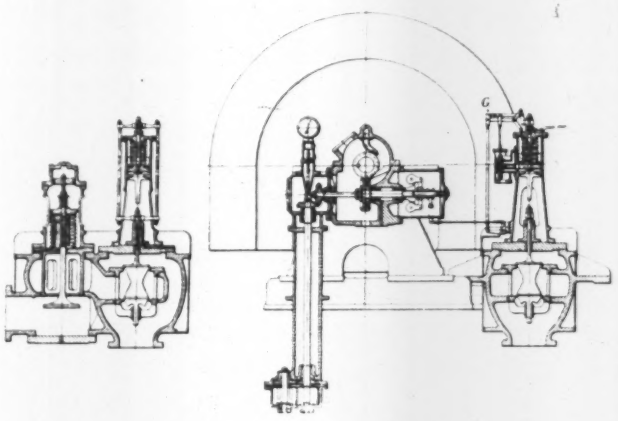

FIG. 4 GOVERNOR TOGGLE MECHANISM

cylinder cover of a "pass-off" turbine, doing away with the separate "pass-off" chest.

SAFETY DEVICES

The matter of safety devices for reheating turbines is considered in some detail.

Operating conditions at the Barking Power Station and on the Parsons machines at Crawford Ave., Chicago, have never demanded the use of these safety devices, but reheat machines in America which did not incorporate them have occasionally given trouble due to overspeeding, and the trend of opinion is definitely in favor of the governor gear.

GENERAL REMARKS ABOUT MODERN MACHINES

Attention is called to the extremely sound lines along which the development of both impulse and reaction turbines has been carried on since the war, leading to the construction of very large machines.

Most turbine manufacturers have now adopted the practice of providing a separate bedplate for the steam chest, connecting the steam chest to the cylinder or nozzle box by a flexible U-pipe. The increase of temperature coupled with increasing sizes has demanded this very desirable flexibility. A noticeable constructional difference between American and Continental practice is becoming evident with the extended use of higher steam pressures. American manufacturers appear to be concentrating on two-cylinder machines, which may be of the tandem or cross-compound type, while several prominent Continental firms are adopting three- or four-cylinder in-line sets with a single alternator. American practice, however, is generally to increase the steam pressure and to keep the total temperature at 750 deg. fahr., while the more recent Continental designs go to 850 deg. fahr. temperature and above in conjunction with higher pressures. A 50,000-kw., 3000-r.p.m. four-cylinder three-exhaust turbine is at present under construction by Messrs. Brown, Boveri & Co. for the Saint-Denis Power Station, Paris, the initial steam conditions being 767 lb. per sq. in. pressure at 887 deg. fahr.

A 4000-kw. turbine for operating at a pressure of 2810 lb. per sq. in. has been constructed by Messrs. Brown, Boveri & Co. for the Langerbrugge Power Station, and much valuable research work is being carried out both in England and abroad, with pressures up to the critical, while very large units are operating successfully in America at 1200 lb. per sq. in. It is understood that American manufacturers have installed or have under construction a turbine plant of a total output of over 500,000 kw. for operating at pressures of 1200 lb. per sq. in. or over.

A very interesting discussion followed the presentation of the paper. This, however, cannot be abstracted because of lack of space. (C. D. Gibb in a paper read before the Institution of Mechanical Engineers, Apr. 17, 1931; abstracted through *Engineering*, vol. 130, nos. 3406, 3407, 3409, and 3411, Apr. 24, May 1, 15, and 29, 1931, pp. 555–557, 587–590, 656–658, and 716–717, 27 figs., *gdhA*. Discussion Apr. 24, pp. 550 to 552; May 1, 1931, pp. 582–583)

Short Abstracts of the Month

AERONAUTICS

Guiding Airplanes by Radio in the Vicinity of Airdromes—The Loth System

IN THIS procedure the transmitter consists essentially of a condenser, the armatures of which are connected by an induction coil. When the condenser receives an initial charge its armatures are discharged across the coil, creating in the latter a magnetic field.

As the discharge current tends to disappear, the self-induction of the coil prolongs the flow of the current and charges the condenser in an inverse direction. With this latter charged once more the phenomena are repeated, likewise in an inverse direction. In other words, the system of the condenser and coil constitutes an oscillating electrical circuit, the oscillations of which create waves propagating in the surrounding space. These waves are received by the airplane by means of a receiving circuit consisting of a condenser and induction coil coupled in the same manner as in the transmitter circuit. One of the armatures in the condenser is comprised of the antennas of the airplane and the other by the entire mass of the airplane. The coil is made in the form of a frame whose plane is horizontal when the airplane is in the normal position of flight. The oscillating electric field produced by the transmitter induces a periodic current in the antenna of the airplane, while the oscillating electromagnetic field, of the same period, induced by the transmitter coil, in its turn produces in the frame of the receiver on the airplane a periodic current lagging with respect to the antenna current. With the proper coupling of antenna and coil, the current which arrives at the receiver of the airplane results in the superposition of the antenna current and the coil current. By means of a Marrec filter the two component currents are equalized in such a manner that if they are opposed in phase they annul each other and thereby extinguish the sound signals produced by the receiver. It is very easy to cause alternately the currents to be in phase and in opposition. All that is necessary is to invert alternately the connection between the coil and the condenser at the transmitting station, for in doing this the electric field is not changed, but every time it is done the direction of the magnetic field is changed. Some rather sketchy details of the layout of the apparatus are given in the original article.

As explained more fully there, theoretically the operation of the device is such that in the first place the pilot is informed of the moment when he crosses the boundaries of the landing field,

and in the second place he is informed of the moment when he has descended to a certain distance above the field. It is claimed, however, by one of the critics of the original paper from which this information is taken, that the precision with which these two important time periods are estimated is quite small. On the other hand, it is claimed that the company exploiting the Loth system has an electrical equipment for landing fields which gives to the pilot not only general information as to the direction toward the center of the field and to the contour of the latter, but also data which permit him to estimate his height above the field.

The Marrec filter, previously mentioned, is described in some detail in the original article. (Paper before the Congress of Aeronautical Security held in 1930, abstracted through an additional article by Ch. Dantin, in *Le Genie Civil*, vol. 98, no. 19, May 9, 1931, pp. 473–475, 5 figs., *d*)

FOUNDRY

The Moore Hot-Blast Cupola

THIS installation was made at the plant of the American Cast Iron Pipe Co. at Birmingham, Ala., and has been in operation since November, 1927.

The conditions of operation are rather trying from the cupola standpoint, as it is demanded that the cupolas furnish maximum speed at some times, while at other times they are required to "stand by," and after a shutdown it is necessary that the first ladle blown up shall be hot. This requirement is primarily responsible for a rather heavy coke burden and equipment for producing high blast, as it is found that with high blast and heavy coke burden this condition can be met.

As the foundry increased its capacity, however, it was apparent that the cold blast must either have the coke reduced to where it could not stand a long shutdown, or else some better means be found for producing high temperatures.

To meet this situation a new design was adopted involving the suspension of a vertical pipe through the abrasion zone of the cupola, blowing the wind in at the top and out through the bottom, one pipe to each tuyere.

The design is illustrated in the original paper, including a description of the experiments to determine the best shape and material for the pipe. A good many varieties of cast iron as well as some heat-resisting steels were tried. The steel pipes soon warped and did not give as good service as cast iron. The iron which seems to give the best results is one of approximately the same composition as ingot molds, i.e., low silicon, high carbon, and low phosphorus. The original article gives records illustrating the relative performance of the cupolas before and after the installation of the hot-blast device.

The cold-blast cupola running on a ratio of $7\frac{1}{2}$ to 1 coke in order to produce the 18 tons required, had to be blown at a blast well in excess of 20 oz. In fact, the average would probably approximate 24 oz. The temperature in the meanwhile was hanging between 1450 and 1460 deg. cent. (2642 and 2660 deg. fahr.) with frequent dips to 1440 deg. cent. (2624 deg. fahr.) and in the case of two considerable periods dropped below 1430 deg. cent. (2606 deg. fahr.), which is too low for the work, and one ladle had to be pigged.

It will also be noted that, due to the high blast pressure after 20 hr., a slag hole blew out and the new one only ran two hours before it also had to be replaced.

In a heat on the hot-blast cupola, the coke ratio being from $9\frac{1}{2}$ to 10 to 1, the melting rate of 20 tons (approximately two tons better than the cold-blast heat) was easily obtained with a blast pressure of 20 oz. or lower. In fact, the average for the shift probably would be 19 oz.

The temperature here shows a decidedly better average, hanging well over the 1460-deg. cent. (2660 deg. fahr.) line, except for one hour—from 3:00 to 4:00 p.m. Here the two pyrometer readers, who read alternately, seemed to be unable to agree, the average being about 1450 deg. cent. (2642 deg. fahr. against a minimum of 1440 deg. cent. (2624 deg. fahr.) One ladle, after a 30-min. shutdown at 3:00 a.m., again read below 1450 deg., but the iron quickly pulled up and reached 1460 deg. on the second ladle.

It is also stated that troubles from bridging and consequent increasing of blast pressure have largely disappeared. (Jas. T. MacKenzie, metallurgist, American Cast Iron Pipe Co., in a paper before American Foundrymen's Meeting at Chicago, May 4–7, 1931, preprint, no. 31–32, 7 pp., 4 figs., *d*)

FUELS AND FIRING

French Colonial Motor Fuels

THE French government, both home and colonial, has been trying to solve the problem of motor fuel for the colonies, as all gasoline has to be imported. Alcohol did not prove successful, and even the attempt to render the use of alcohol compulsory by obliging importers of gasoline to purchase from the state a quantity of alcohol equal to 10 per cent of the gasoline imported had to be abandoned. But efforts to secure a place for alcohol as a fuel are continuing. Among other things, it has been suggested that a mixture of alcohol and glycerine from vegetable oils might be a suitable lubricant.

Vegetable oils are debarred from industrial use on account of their acidity, and a catalytic method of obtaining motor spirit from such oils has failed commercially. Catalytic production of motor spirit is, however, possible in cases of emergency. The application of charcoal suction gas is also at a standstill, though work is continuing. Panhard and Levassor have adapted the high-speed engine to suction gas, and makers of wood-carbonizing plants are devising generators on more rational lines. In the colonies there are regular services of charcoal-suction-gas vehicles, and even in France a number of such vehicles are in operation.

In the designing of new suction-gas plants the troubles, such as irregularity in operation, revealed by experience are being eliminated, and at the Congress importance was attached to the rapid production of gas by the blowing of air through the incandescent mass. The suction-gas generator is being improved with the running of suction-gas vehicles. Makers aim at producing smaller and lighter generators capable of working with greater regularity. It is claimed that the complete suction-gas equipment for a 3-ton lorry can now be reduced to 300 kg. (660 lb.).

The trouble with charcoal lies partly in the fuel itself. The absorption of moisture in the humid atmosphere of the tropics is a serious difficulty in some colonies. It is also a drawback in France, where the user of charcoal often pays for an unduly high water content. The carbonization of wood is not sufficiently economical unless it is effected in works which utilize the by-products. They obtain practically four equal parts of charcoal, by-products, water, and gas, and the by-products are, of course, the most valuable. For motor traction in the colonies, and even in France, the user must be able to produce his own charcoal. Otherwise the home user is at the mercy of irregular supplies as well as varying prices.

Therefore wood-carbonizing plants are being improved in the same way as the other suction-gas-vehicle equipment. New systems of carbonizing plants were presented at the Congress held at the International Colonial Exhibition. They are designed upon more scientific lines than the old appliances, and there is no doubt that if little advance has been made in the actual use of suction-gas vehicles, the progress being accomplished in engines

and generators is preparing the way for a more extensive employment of suction-gas lorries in the future.

Attempts are being made to avoid the inconveniences of charcoal by substituting for it "torrefied" wood, and this appears to have improved considerably the prospects for the suction-gas vehicle. The really encouraging results obtained so far are due to the experiments of Professor Dupont, of Bordeaux, who is associated with the Forestry Department in the Landes. He determined the conditions under which the wood should be torrefied so that it should preserve the heat units that are lost when the wood is carbonized in the form of charcoal. The operation is a delicate one, because the temperature must be maintained at between 270 deg. to 300 deg. cent., during which time plaster or lime or some other ingredient is introduced to act as an absorbent of water contained in the wood. Monsieur Bourdet presented an apparatus for insuring automatic torrefication of the wood and a distillation of the cellulose without risk of its passing into the state of charcoal. For this purpose the wood is cut up small, which makes it still more convenient for suction-gas plants. After treatment the wood retains its natural dry color, without trace of carbonization. One ton of green wood will produce 700 kg. of torrefied wood, and the heat units given off by combustion are stated to be one-third more than those of charcoal. The cost of the torrefied wood is said to be approximately £2 per ton. (*The Engineer*, vol. 151, no. 3933, May 29, 1931, p. 594, *g*)

HANDLING AND CONVEYING MACHINERY

A Sidewise-Curving Conveyor Chain

THE Link Belt Company has placed on the market a conveyor chain so constructed that it will curve sideways around corners and S-curves. It is said that it will travel in a horizontal plane around curves of 90 deg. to 100 deg. with perfect freedom under full load, and with a curve of a radius as small as 24 in. Due to the chain's flexibility it may be used on sprockets as small as 7½ in. pitch diameter. The chain is of the pintle type. The barrel of the link (Fig. 1) contains a universal joint which permits the sideways flexing of the chain. (*Link Belt News*, May, 1931, p. 7, 3 figs., *d*)

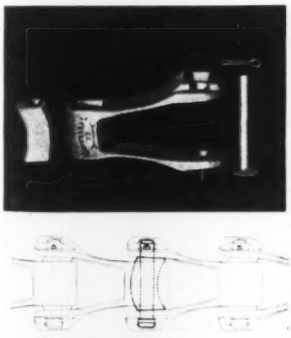

FIG. 1 CONVEYOR CHAIN WHICH MOVES SIDEWAYS

INTERNAL-COMBUSTION ENGINEERING (See also Fuels and Firing: French Colonial Motor Fuels)

Engine Performance at High Compression Ratios

THE object of the tests described in the article under consideration was to give definiteness to some generally accepted facts regarding engine performance at high compression ratios. The intention was to measure as well as to indicate the general effect of certain engine factors.

The N.A.C.A. universal test engine was used in the tests. This is a single-cylinder, variable-compression engine designed by the National Advisory Committee for Aeronautics. Several of the engines were originally built and are now being used in different parts of the country. Accounts of the engine have been published from time to time, so that its construction is generally familiar, but in order to make this material available to the readers, a description of the engine is included.

The engine has a 5-in. bore and a 7-in. stroke, giving it a displacement of 137.45 cu. in. The cylinder barrel with water jackets is a separate part and is bolted to the cylinder head. The outside of the cylinder proper is also machined, and this sits inside an outer stub wall. By means of a worm-and-thread arrangement it is possible to move the cylinder and head assembly up and down, which varies the clearance space above the piston and provides the variable-compression feature. The compression ratio may be varied at any time whether the engine is running or not.

The first observation is that detonation, when first encountered, does not lower the power output of the fuel. On the contrary, the power increases slowly until the detonation becomes extremely severe at each explosion. A point is then reached where the power drops sharply. This power-drop point is not necessarily the point of auto-ignition.

For ordinary use, however, it is not advisable to operate an engine under detonating conditions, unless for very short intervals of time. Detonation puts severe shock loads on all parts concerned, and creates an abnormal heat condition which the engine may or may not be able to meet. In addition it is disturbing to the occupants of the car.

The second and more important observation is that, assuming that an engine is to be operated at a point of constant detonation intensity, no increase in power may be obtained by an increase in compression ratio unless the fuel is changed. If the compression ratio were to be increased and the spark reset to the constant detonation intensity, the power output would be approximately the same as before. This holds true for all compression ratios high enough for the limit of detonation intensity being studied to be reached before the maximum power point. On this particular engine and with the fuel used in these tests, that means all compression ratios above 4.5 to 1.

In general, the tests have shown that if a high-compression engine is equipped with an adequate spark control, it will be possible to use either ordinary or superior anti-knock fuels at high compression ratios without loss of power on the same engine. This should give the high-compression engine a real advantage over the engine having a lower compression ratio. (H. E. Zuck, Department of Engineering Research, University of Michigan, in *Engineering Research Circular No. 6*, March, 1931, pp. 7–31, 13 figs., *e*)

Carburetor Fuel-Metering Characteristics

IT HAS been suggested that the variation in mixture strength caused by change of fuel temperature may be reduced by fitting sharp-edged (knife-edged) fuel-metering orifices to carburetors. In the absence of information as to the magnitude of the change of mixture strength to be expected with the range of temperatures likely to occur in flight, tests on a standard type of carburetor were made to obtain data.

A carburetor (Clauden Hobson type A.V. 48.C) suitable for an 80-hp. engine was calibrated using 80/20 petrol benzol mixture at various temperatures, kerosene, and white spirit. A constant inlet-air temperature was maintained throughout the test to reduce variation due to change of air density. The coefficients of discharge for the various orifices were determined over a range of conditions from flow tests apart from the carburetor.

At full throttle the carburetor as supplied showed very little change of mixture strength with fuel temperatures from +20 deg. cent. to —30 deg. cent. over an air-flow range such as is likely to occur in service. At part throttle there was considerable weakening with decreased temperature. Over a larger temperature range, +20 deg. cent. to —50 deg. cent., weakening of the mixture

strength with temperature occurred, especially at the low air flows and at part throttle. When fitted with sharp-edged orifices the mixture became rich with decreased temperature, the increased mixture strength being greater than the variation given by the original jet at full throttle, but less at part throttle.

Flow tests of jets (not fitted to the carburetor) with various-shaped orifices showed that sharp-edged orifices have constant discharge coefficients over a large temperature range, and consequently give rich mixtures at low temperatures due to the increased density. (W. C. Clothier in *Department of Scientific Research, Air Ministry, Great Britain, Reports and Memoranda No. 1361, E 43*, December, 1930, original 12 pp. and 37 diagrams, abstracted from official communication, *e*)

MACHINE PARTS

A New Variable-Speed Transmission

THE device invented by Wallace M. Cutler, Cambridge, Mass., makes use of a planetary gear train, somewhat similar to that in the old Ford transmissions. In such a gear train, as is well known, the speed of the driven gear is dependent not merely on that of the driver. It depends also on that of another gear, which in most applications is held stationary.

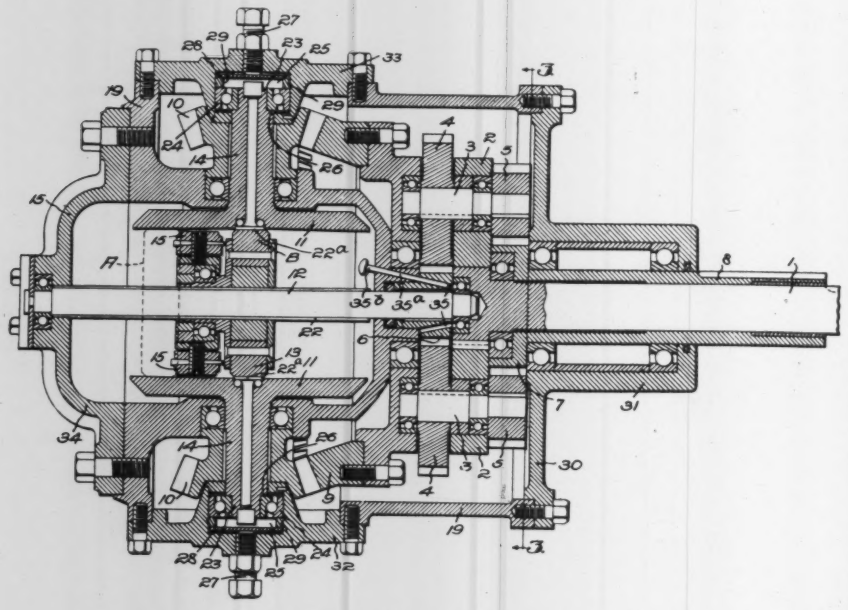

FIG. 2 THE CUTLER VARIABLE-SPEED TRANSMISSION

In the Cutler transmission this gear is turned through a friction drive, its speed depending on the setting of the disks. There is one position at which it is stationary, and at that speed all power goes through the gears. Departing from this speed either way, a greater and greater amount of power is taken by the friction drive. There is another position where the speed is zero, and beyond that the driven shaft is reversed. (Description taken from a communication submitted by the inventor, *d*)

MECHANICS

Dynamical Analysis of Machines

THE author considers such subjects as oscillations of a linkage mechanism similar to a governor linkage which is rotated about a vertical shaft with a certain angular velocity. He considers next the dynamic equations for a system of vibrating disks, showing incidentally that the lateral and torsional vibrations of such a system are not independent except for a special case.

The characteristic of vibrations is affected by the degree of elasticity of the bearings, and the author considers the relations of the elastic coefficients, giving a process of analysis required in the more complex problems in the applications of Castigliano's theorem.

An interesting part of the article is devoted to the discussion of the energy method in shaft analysis.

It is well known that the whirling speed of a shaft corresponds to the natural frequency of vibration for lateral vibrations. Good approximations for the fundamental frequency are obtained by assuming an arbitrary deflection curve of the shaft and equating the maximum strain energy in its deflected position to the maximum kinetic energy in its neutral position. This method was introduced by Rayleigh, and Morley applied it to the shaft problem, assuming the deflected curve to correspond to its static deflected position.

When, however, this method is applied to disks subjected to angular vibrations sufficiently small so as not to affect the deflected curve corresponding to lateral vibrations alone, the natural frequency is found to be lowered, whereas actually the whirling speed is raised.

If the rotational speed is included in the expression of the kinetic energy for a deflected disk, Chree regarded the whirling speed as that speed for which the frequency of vibration becomes nil, that is, the critical speed at which the shaft ceases to vibrate. Lorenz, Föppl, Lees, and others consider the critical speed with a slightly unbalanced disk simply as a condition of resonance — that is, when the forced vibration resulting from the centrifugal loading coincides with the natural frequency.

The author regards the whirling speed as a condition of kinetic instability. The condition of stability approximating the critical speed means that the total input into the shaft and the work of the internal elastic reactions do not exceed the rotational kinetic energy at the maximum deflected position. If this work exceeds the rotational kinetic energy at the deflected configuration, the condition of instability results. Therefore the whirling or critical speed corresponds to that speed at which the work done on the shaft from its neutral or undeflected position to its deflected position, including the corresponding change in the elastic potential, is just equal to the rotational kinetic energy alone in the deflected position. The author regards the work from the neutral to the deflected position to occur approximately at the critical speed.

The author first disregards the angular turning of the planes of the disks and then considers it, assuming the deflection to occur at synchronous precession under certain assumptions, and finds the expression for the impressed torque on the shaft and for the whirling speed and natural frequency, the latter being derived so as either to take the gyroscopic effect into consideration or neglect it.

Next are considered the inertia coefficients and velocity ratios. The author derives equations of motion expressed in terms of inertia coefficients, and employing the Lagrangian equations, he derives equations of his own, the form of which are the basis of the Christoffel notation. He shows, however, that equations in terms of partial velocity ratios which he derived from D'Alem-

bert's principle can also be derived from a consideration of the inertia coefficients in these equations. He ultimately derives a generalized equation of motion in terms of partial velocity ratios for three degrees of freedom for the three coordinates. He arrives at the following conclusions:

The subject of dynamics of machinery offers a particular theoretical field for the application of general dynamical methods in a category quite comparable to gyrostatics and similar provinces in dynamics. Considering its practical importance, it is fundamental in the field of technical engineering and offers a very unique field in applied physics.

A primary object of these articles has been to maintain only the theoretical aspects of the subject as a branch of general dynamics. The development in this work of the dynamical equations directly in terms of velocity ratios and their derivations for both one and several degrees of freedom is of particular use in the specialized subject of dynamics of machinery. It gives a connecting link between the now separate but well-developed field of engineering kinematics and the dynamics of mechanisms. The preliminary analysis, however, offers considerable extension in both analytical and graphical procedures. Emphasis has also been laid on the use of redundant coordinates with the equations of conditions or constrained velocity relations as a procedure of determining constraint reactions and internal reactions in a mechanism.

Other branches of this subject that await considerable development are the application of gyroscopic theory in machinery, mechanical devices, and control apparatus. Also, an important phase is in connection with the oscillations of mechanical electromagnetic systems in control apparatus and with prime movers, synchronous motors, etc., in complex electric power systems. The field of vibration of machinery is under way, but it will always have a fertile field of many applications and further extension in theory.

Very closely connected with the subject and really an integral part pertains to the study of electromagnetic reactions and fluid dynamics. (R. Eksergian, Mem. A.S.M.E., in an extension of a portion of a dissertation for the degree of Doctor of Philosophy, submitted to Clark University, 1928; abstracted through *Journal of The Franklin Institute*, vol. 211, no. 5, May, 1931, pp. 627–650, and bibliography, pp. 651–652, *mA*)

POWER-PLANT ENGINEERING

Benefits That Warranted Pennsylvania Electrification

THE National Coal Association has challenged the Pennsylvania Railroad to justify the electrification of its railroad and has shown a general tendency to attack the economic justification of industrial electrification.

The *Electrical World* has asked the Pennsylvania Railroad to explain why it chose to supplant steam with electrical operation, and also why the National Coal Association's criticism is unjustified. Because of the importance of the subject and the great value of the plant involved, the reply of the Pennsylvania Railroad is here reproduced in part.

Three years ago General Atterbury pointed out the following factors which influenced the Pennsylvania's decision to electrify:

1. Greater economy of electric traction as compared with steam operation in dense traffic territories.
2. The growth of the Southern passenger business.
3. The increasing density of both freight and passenger business on our Eastern lines, and the probability that in the future more rapid movement would be required.
4. The desirability of utilizing the advantages of electric traction in connection with the construction of our new passenger terminals at Philadelphia and Newark.
5. The desirability of building a locomotive that would meet the requirements from the standpoints of weight of train, speed, and reliability that we believe will have to be met in this territory in the next twenty years.

General Atterbury additionally stated that on the basis of the traffic estimated for the year 1935 the probability was not lost sight of that by 1950 the Metropolitan area around New York would extend to New Brunswick on the west and well out on Long Island on the east, and contain thirty million people. There would be similar developments in other cities. The system of electrification adopted will permit handling a movement of any magnitude which it is possible to handle over the existing tracks, and at such speed within the points necessary for safe operation as the demands of the traffic may require from time to time. It is expected eventually to reduce the number of freight trains 50 per cent for a given car movement, which, together with increase of speed, provides for a 100 per cent increase in capacity in so far as freight movement is concerned.

It is true that electrification of the Pennsylvania lines will eliminate a certain amount of coal consumption in locomotives now using steam power. This loss will be largely counterbalanced, however, by the consumption of coal by electric power plants furnishing the necessary electricity to operate the Pennsylvania's electrified system. Since the electrification is expected to bring new and increased traffic to the Pennsylvania lines, it is logical to assume that the amount of power required by the Pennsylvania's electric operation will considerably increase the amount of coal consumed in the generation of electrical power in that territory.

It is also entirely conceivable that if, as the National Coal Association states, "industries in the same section will likewise turn to that source of energy (electrical power) instead of generating their own power by the use of coal," additional large industries may be attracted to this section by the supply of cheap electric power, thus bringing into the territory an additional demand for power and consequently a similar increase in the consumption of coal needed to generate this electricity.

Any decrease in coal tonnage on the Pennsylvania Railroad caused by a switch from steam to electric power on the part of industries located along its lines will also be largely offset by the elimination of all expense for hauling coal for its own locomotive use, due to the substitution of electric for steam power.

Power plants which will supply the Pennsylvania Railroad with electric current will probably be located along the railroad, and it is a natural assumption that the Pennsylvania Railroad will haul a very considerable portion of the coal tonnage used by these plants.

The coal industry has benefited rather than suffered from the use of electricity by railroads. The use of the electric light, replacing candles, kerosene, and gas, has increased the consumption of coal for electric-light and power purposes tremendously. Railroad stations, offices, shops, and cars are lighted by electricity. Shop machinery is almost entirely operated by electricity. Signal systems and scores of other railroad operations are today powered by electricity. All of this current requires coal to generate it. (*Electrical World*, vol. 97, no. 17, Apr. 25, 1931, pp. 769–770, *g*)

RAILROADS (See also Power-Plant Engineering: Benefits That Warranted Pennsylvania Electrification)

The Lehigh Valley Streamlined Locomotive

THIS locomotive was built for the Lehigh Valley Railroad Company by the American Locomotive Company, and is of interest in that the usual piping is almost entirely missing from the sides of the boiler.

This new engine is capable of hauling full-tonnage freight trains at unusually high rates of speed, or it may be used to handle extra heavy passenger trains and thereby maintain the regular schedule.

The locomotive is so designed as to be best fitted for operation on long no-stop runs—the tender has a capacity of 18,000 gal. of water and 28 tons of coal. No "helper" engine will be required to assist this engine in hauling freight or passenger trains through mountainous territory. It has a four-wheel trailing truck, four pair of drivers, and a four-wheel trailing truck—a so-called 4–8–4 wheel arrangement. Cylinders are 26 × 32 in., and the steam pressure 255 lb., while the driving wheels are 70 in. in diameter. Together with its booster, it can develop a starting effort of 85,060 lb.

Over all, it is approximately 108 ft. in length, and with its tender weighs 780,800 lb. In designing this engine there has been included the most modern safety power-producing and fuel- and labor-saving devices.

The other general dimensions are given in a table in the original article. (*Railway Journal*, vol. 37, no. 5, May, 1931, p. 17, 1 fig., *d*)

REFRIGERATION

Experimental Installation for the Investigation of Ammonia-Water Mixtures

THIS installation was organized at the instigation of Professor Merkel who loaned his assistance to the work until his death in September, 1929. The purpose of the investigation was to determine the relations between boiling pressure, boiling temperature, and composition of the two-material mixture as well as the equilibrium composition of the liquid and vapor phases and also the specific volume of the dry saturated vapor.

The first two sets of tests could be carried through in one series, while the determination of the specific volume required a series of tests of its own. It may be mentioned in this connection that while very little experience is available in calibrating the installation for this purpose, it was determined to undertake it nevertheless.

In an experimental work of this type done previously glass vessels were used. If comparatively high pressures had to be dealt with it became necessary for reasons of strength to make the vessels quite small, which carried with it certain disadvantages.

Thus, it is only with difficulty that a thermometer can be then introduced into the vessel itself, with the result that the investigator has to content himself with the measurement of the temperature of the bath, but in the case of a water bath, which is simple to handle, the limit of temperature is only 100 deg. cent., while if an oil bath is used, considerable trouble arises in the matter of handling.

If steam samples are taken the composition of the liquid varies materially, as it contains always a smaller proportion of the easily boiling constituents than the steam. The size of vapor samples depends on the method used for determining the composition of the vapor, and the smaller the size of the vessel, the greater becomes the influence of the size of the vapor sample on the composition of the liquid. Moreover where the vapor space is small there is great danger that droplets of the fluid will be carried over and by their presence falsify the determination of the concentration. Simultaneously with this, because of after-evaporation, some heat from the bath flows into the material in the vessel, which produces a difference in temperature, and under these conditions the temperature of the bath can no longer be considered as a reliable basis of measurement. In the determination of the specific volume the wells of the vessel must have the same or a higher temperature, as otherwise there will occur either local superheating or local condensation. This is difficult to achieve in the case of glass parts projecting from the bath, and furthermore as it is necessary to work with small amounts that must be weighed, a large vessel is preferable in the interests of precision. Because of the above considerations the present investigators decided to use an iron vessel which can be made sufficiently large and which had an additional advantage in that all indications pointed to the fact that the material of the wall of the vessel affected the boiling temperature—and in particular work one has to deal chiefly with iron vessels, which made it particularly desirable to use them also in the determination of the physical constants.

The use of the iron vessel brought with it certain disadvantages. One cannot see what is going on inside the vessels. Calking the vessel is difficult, and finally the whole apparatus becomes fairly large and heavy. The construction of the various parts presented certain problems as well. The article tells how these have been solved. The description of the installation cannot be abstracted because of lack of space.

The results of the measurements are not given, but it is stated that in the matter of measurements of temperature and pressure the full precision possible has not yet been attained. On one hand, the determination of the concentration has not yet been entirely satisfactory, which was due less to the method of its determination (titration) than to other factors. Certain disadvantages in the experimental methods have been also discovered. Among other things, in order to reduce the number of tests in each test several temperatures were tried. In the case of heating, starting from the lowest and ascending and in the case of cooling, vice versa, while the lead of the thermometer by reckoning and experiment was under 0.1 per cent but did not prove possible to get the temperatures in the liquid and vapor spaces exactly alike, the vapor always lagging.

In the case of a temperature change of about 0.2 per cent minimum, the undercooling of the vapor space in the case of heating was from 0.2 to 1 per cent and the superheating in the case of cooling from 1 to 4 per cent. Notwithstanding its smaller magnitude the undercooling is the more troublesome, because on account of partial condensation it leads to changes in the composition of the steam, which is not affected by superheating.

The authors used the dynamic method, which they say presented a certain disadvantage. It led to the occurrence of a superheating of the liquid as compared with the static boiling point, which latter is particularly independent of the velocity of evaporation and under the conditions of the experiments should have amounted to about 0.2 to 0.3 deg. cent.

In single materials, where the vapor condenses at constant temperature, its temperature indicates the static boiling point; this, of course, is not the case with mixtures, and the results become uncertain because of preheating.

The scattering of the test results within each single test was quite slight—on the average maximum of 0.1 per cent, but as between tests it amounted to from 0.3 to 0.5 per cent. This represents the precision obtainable with the installation and methods used in the investigation here described, as applied to the case of a mixture of substances with such widely spaced boiling points as water and ammonia. The authors claim, however, that the precision attained by them is sufficient for practical purposes, and that a greater precision could be obtained by a much greater expenditure in the way of time and apparatus, which they consider to be hardly justified. (F. Bošnjakovič and J. Wucherer in *Zeitschrift für die Kälte Industrie*, vol. 38, no. 5, May 9, 1931, pp. 65–69, 5 figs., *e*)

STEAM ENGINEERING

Oscillatory Movements of Steam in Boilers

IN BOILERS and evaporators from time to time hammer blows have been observed which are repeated at periodic intervals. These have been generally ascribed to oscillations of the mass of the steam, without, however, any explanation being given as to how they originate. To show this is the purpose of the present article. The following notation referring to Fig. 3 is employed:

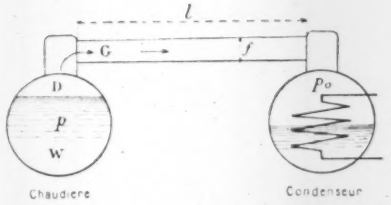

FIG. 3 DIAGRAM COMPRISING BOILER AND CONDENSER (*chaudière*-boiler; *condenseur*-condenser.)

W = weight of water in the boiler in kg. (This is shown in Fig. 1 as W)
D = weight of steam in the boiler in kg.
G = output of steam in kg. per sec.
Q = quantity of heat delivered in kg-cal. per sec.
V = volume of boiler in cu. m.
p = pressure in the boiler in kg. per sq. m.
p_0 = pressure in the condenser in kg. per sq. m.
ω = velocity of flow of steam in the pipe in m. per sec.
l = length of pipe in m. per sec.
f = cross-section of the pipe in sq. m.
t = time in sec.
q = heat of the liquid in kg-cal. per kg.
i = heat in the vapor in kg-cal. per kg.
γ_ω = specific weight of water in kg. per cu. m.
γ_d = specific weight of steam in kg. per cu. m.
g = acceleration due to gravity = 9.81 m. per sec.^{2}

One may write for the heat balance of the boiler,

$$Qdt = Gidt + Wdq + Dd(i + q) \quad [1]$$

For the balance of the weights of the boiler,

$$dD + dW + Gdt = 0 \quad [2]$$

For the balance of the volumes of the boiler,

$$V = \frac{W}{\gamma_\omega} + \frac{D}{\gamma_d} \quad [3]$$

For the equation of continuity in the pipe,

$$G = f\omega\gamma_d \quad [4]$$

The dynamic equation relating to the flow of steam in the pipe is

$$\left(fl\frac{\gamma_d}{g}\right)\frac{d\omega}{dt} - f(p - p_0) - \left(4\rho\frac{1}{d}\frac{\gamma_d}{2g}\right)\omega^2 = 0 \quad [5]$$

In these equations G, W, D, p, and ω are quantities which depend on the time t. The quantities γ_d, γ_ω, i, and q are known functions of pressure p. In the form given above these equations are not suitable for integration. To put them into shape so that they can be integrated the author makes the following changes. In the first place the weight of water in a boiler is always very much greater than the weight of steam, and hence the quantity D can be neglected by assuming $D = 0$.

Second, if the boiler is not too small the weight of water which it contains varies very slowly. For practical purposes, therefore, it may be assumed that W = constant.

Third, to facilitate the solution of the problem it may be assumed where variations of pressure are very small that the quantities i and γ_d are likewise constant.

Fourth, the heat of the liquid q may be assumed to be a linear function of p; i.e., $q = q_0 + a_q p$; $dq = a_q dp$

Fifth, one may neglect the friction of the steam in the pipes, i.e.,

$$\left(4\rho\frac{l}{d}\frac{\gamma_d}{2g}\right)\omega^2$$

After the simplifications the above differential equations take the following form

$$Qdt = Gidt + Wa_q dp \quad [1']$$

$$G = f\omega\gamma_d \quad [4']$$

$$\left(fl\frac{\gamma_d}{g}\right)\frac{d\omega}{dt} - f(p - p_0) = 0 \quad [5']$$

It is now necessary to calculate G, ω, and p as functions of the time. To do this the author transforms the above equations into the following differential equations:

$$\frac{d^2G}{dt^2} + \left(\frac{r_0 gf}{Wa_q l}\right)G - \frac{Qgf}{Wa_q l} = 0$$

$$\frac{d^2\omega}{dt^2} + \left(\frac{r_0 gf}{Wa_q l}\right)\omega - \frac{Qg}{Wa_q l\gamma_0} = 0$$

$$\frac{d^2p}{dt^2} + \left(\frac{r_0 gf}{Wa_q l}\right)p - \frac{fgr_0 p_0}{Wa_q l} = 0$$

As the coefficients of G, ω, and p are positive, the solutions of these equations take the following forms:

$$G = A_1 \sin \beta t + B_1 \cos \beta t$$
$$\omega = A_2 \sin \beta t + B_2 \cos \beta t$$
$$p = A_3 \sin \beta t + B_3 \cos \beta t$$

β is the same for all three equations, namely,

$$\beta = \sqrt{\frac{r_0 gf}{Wa_q l}}$$

From the above it would seem that the boiler and pipe behave as an oscillating system. There is an exchange of energy to the effect that the pressure in the boiler varies with the velocity of flow of steam in the pipe, and vice versa. This explains why even during steady heating (Q = constant) the output of steam G may oscillate. If the variations of G become very great the entire content of the boiler gets into violent agitation and large amounts of water are entrained into the pipe. It is the water thrown out of the pipe that produces hammer blows.

The oscillations originate in the following manner. At first the boiler operates steadily. Then for some reason or other firing is pushed up for a short time. This results in an increase of pressure in the boiler and hence an increased output of steam, as the latter increases proportionately to $\sqrt{p - p_1}$. Then the steady rate of firing is reestablished, but the steam flowing into the pipe has acquired a certain acceleration and the output of steam is greater than that which should be maintained during the steady rate of operation. This results in a tendency of the pressure in the boiler to drop, with a resultant decrease in the output of steam and also in its velocity of flow. As the firing of the boiler does not change, the output of steam becomes less

than the normal value, the pressure in the boiler increases, and the same cycle of events is repeated. If there are no new fluctuations in the rate of firing the oscillations die out as a result of the friction in the pipes, but if the fluctuations in the firing follow the same rhythm as the oscillations in a system comprising the boiler and pipe expressed by

$$\left(\beta = \sqrt{\frac{r_0 gf}{W a_0 l}}\right)$$

violent vibratory phenomena may occur which are sufficiently powerful to cause water hammer and otherwise make trouble. (Roman Selikin in *Le Genie Civil*, vol. 98, no. 19, May 2, 1931, pp. 456–457, 1 fig., *m*)

THERMODYNAMICS (See also Refrigeration: Experimental Installation for the Investigation of Ammonia-Water Mixtures)

Heat Transfer of Liquids in Viscous Flow

THIS paper deals with the subject of heat transfer in the case where the fluid moves at a velocity below the isothermal critical velocity. This field has not been extensively investigated in the past. The present paper reports new experimental data and correlates these and other existing data with the Nusselt and Gröber theory of heat transfer to fluids in viscous flow.

In his investigation on the program Nusselt makes two assumptions: First, the tube wall is smooth and, second, the flow is viscous and the velocity distribution over any cross-section is a paraboloid of revolution as given by a formula which he derived. Nusselt makes two other assumptions as to heat developed by friction and temperature gradient. The authors consider that the second of these assumptions is questionable.

In the present paper the experimental results are compared with the theoretical calculations of Nusselt and Gröber. Among other things the authors derive equations by which turbulent-flow heat-transfer data can be correlated with viscous-flow transfer data, while one of the equations—No. 20 in the original article—can be used as a general type equation for heat transfer under both viscous- and turbulent-flow conditions. (G. G. Kirkbride and W. L. McCabe, Dept. of Chemical Engineering, University of Michigan, Ann Arbor, Mich., in *Industrial and Engineering Chemistry*, vol. 23, no. 6, June, 1931, pp. 625–631, 4 figs., and brief list of references, *e*)

TESTING AND MEASUREMENTS

Fine Testing Sieves

THE British Standard Specification for Test Sieves (No. 410, 1931) has recently been issued by the British Engineering Standards Association. This specification divides such sieves into three classes of fine, medium, and coarse, and tables are given covering these.

The gradation which has been adopted for the size of the apertures in this specification is based on a difference in linear measurement in the ratio of $\sqrt[4]{2} : 1 = (1.188 : 1)$ between consecutive sieves, which is the basis of the series which has been adopted by the U. S. Bureau of Standards. The original article gives a series resulting from this aperture ratio in which the linear measurement of any sieve aperture is twice that of a sieve four places above it in the series, which the author illustrates graphically.

Except to the sieve manufacturer the linear dimensions of the apertures are not in themselves most important. It is the ratio of the areas of the apertures which is of importance. A table has been drawn up for the ratio comparison of the British standard apertures with those of the American Bureau of Standards, the German and Polish tables, and the I. M. M. standard (Table 3 in the original article). For America it gives data for the U. S. Bureau of Standards, Tyler, and Ludlow Saylor. The U. S. Bureau of Standards table is said to be a theoretical one which does not allow of practical applications, and the practice in the United States is to use Tyler's or Ludlow Saylor's, which have apertures very similar to those in the standard tables but make use of slightly different wires.

In compiling and comparing records of tests it is very desirable to have full data of the sieves used, the method of sifting, the time taken, quantity used, etc. The method may consist of a definite number of shakes by hand, or a fixed time in a standard machine, and may be aided by "floats" of "scrubbers" or a brush. If one sieve only is used, such as where a material is described as "passing a 100-mesh British Standard sieve," the size of particle may be anything from 0.066 in. in diameter to some indefinitely small figure, and the bulk may, in different tests, lie near to opposite extreme of the limits, so that accuracy of comparison of results is impossible. This applies to some extent, of course, where "pass" and "remain" sieves are quoted, diminishing as these more closely approach each other in size. Where the two sieves do closely approach each other in aperture size, it may be assumed that the average particle size is practically midway between the two aperture sizes. Microscopic examination can, of course, be resorted to where very accurate comparisons are desired. Since workshop sieves and methods are liable to be distinctly less accurate than those of the laboratory, a material specified to be between two limits, e.g., 100 mesh to 150 mesh, may conveniently be sifted on sieves a little inside these limits, such as would be obtained by the use of 110- and 140-mesh sieves of proportionate aperture, thus allowing for small differences and insuring satisfactory results at inspectors' test. This may not give the exact product specified, but the average size of particle should be the same, and in practice this is found to work quite well.

There is no standard method of sifting available. Materials with a low angle of repose will usually flow freely through if the sieve is shaken; others require the sieve to be tapped frequently in addition, and some require the use of a brush or scrubber applied more or less vigorously. The moisture content is also an important factor.

As regards weaving tolerances, the foreword to the new specification explains the difficulties experienced in fixing these and the rather unsatisfactory position due to the present wide range, the hope being expressed that greater accuracy will be attainable in the future. How far such tolerances affect results is at present unknown, and is beyond the scope of these notes, but it is felt that very useful work might be done in determining this, which, in turn, would lead perhaps to greater accuracy in manufacture.

Some years ago the author of the present paper proposed a series of cloths based on the formula $D = 1/2.5M$, where D is the diameter of wire and M the number of apertures per linear inch. This gives a screening area of 36 per cent, and it is to be noted that the new specification for fine-mesh sieves, to which these remarks are confined, gives screening areas varying between 35 per cent and 44 per cent. The percentage of screening area is that proportion of the total surface area of the screen which is available for particles to pass through—that is, the area not occupied by wires. If this figure is as high as about 50 per cent for fine screens, the sieve is apt to be low in strength and liable to lose rigidity, the wires shifting their position and thus causing wear and irregularity in size of aperture. If it is down in the region of 25 per cent (I.M.M. Standard Series), great difficulty is experienced in weaving, due to the great amount of work to be done on the wire. (P. E. Masters in *Engineering*, vol. 131, no. 3410, May 22, 1931, pp. 659–660, 2 figs., *g*)

Instruments and Apparatus

Preliminary Draft of Part 5—Measurement of Quantity of Material

The Main Committee on Power Test Codes takes pleasure in presenting to the members of the Society for criticism and comment Part 5, Measurement of Quantity of Material. The Individual Committee which has developed this draft consists of Messrs. C. F. Hirshfeld, Chairman, W. A. Carter, Secretary, C. M. Allen, E. G. Bailey, L. J. Briggs, C. R. Cary, J. D. Davis, R. E. Dillon, F. M. Farmer, J. B. Grumbein, W. H. Kenerson, E. S. Lee, E. L. Lindseth, O. Monnett, S. A. Moss, R. J. S. Pigott, E. B. Ricketts, and W. A. Sloan.

The "Instruments and Apparatus" Section will consist of twenty-one parts dealing with the following subjects: (1) General Considerations,[1] (2) Pressure Measurement (6 chapters),[2] (3) Temperature Measurement (9 chapters),[3] (4) Head Measurement, (5) Measurement of Quantity of Material, (6) Electrical Measurements, (7) Mechanical Power, (8) Measurement of Indicated Horsepower, (9) Heat of Combustion, (10) Flue-Gas Analysis, (11) Determination of Quality of Steam,[4] (12) Time Measurements, (13) Speed Measurements,[5] (14) Mechanical Measurements, (15) Surface Area, (16) Density Determinations,[6] (17) Determination of Viscosity of Liquids,[7] (18) Humidity, (19) Concentration of Dilute Solutions, (20) Smoke-Density Determinations, and (21) Leakage Measurements (2 chapters).[8]

Complete copies of the draft which is published here in abstract may be obtained from the Society's headquarters. The Individual Committee, the Main Committee, and the Society will welcome suggestions for corrections or additions to this draft from those who are especially interested in this subject. These comments should be addressed to the Chairman of the Committee, in care of The American Society of Mechanical Engineers, 29 West 39th Street, New York, N. Y.

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CLASSIFICATION

1 It is convenient to classify the existing methods of measurement of quantity of materials under headings as follows:

I SOLIDS—WEIGHING ONLY

1 Scales, Manually Operated
- (*a*) Platform type—indicating or recording
- (*b*) Hopper type—indicating or recording

2 Scales, Automatic Indication
- (*a*) Platform type—indicating or recording
- (*b*) Hopper type—indicating or recording
- (*c*) Conveyor type—indicating or recording

II LIQUIDS—WEIGHING, VOLUMETERS, AND FLOWMETERS

1 Weighing scales
- (*a*) Manually operated tank type
- (*b*) Automatic tank type

2 Volumeters
- (*a*) Tank type
- (*b*) Piston meters
- (*c*) Disk meters
- (*d*) Rotary meters
- (*e*) Metering traps

3 Mechanical or Kinetic Meters
- (*a*) Turbine meters
- (*b*) Anemometers

4 Flowmeters
- (*a*) Venturi type
- (*b*) Disk-orifice type

[1] See pamphlet published in June, 1928.

[2] Chapter 1 of Part 2 on "Barometers," was published in pamphlet form in June, 1929.

Chapter 6 of Part 2, on "Table, Multipliers, and Standards for Barometers, Mercury and Water Columns, and Pressure Measurements" was published in pamphlet form in June, 1929.

[3] Part 3, Chapter 1, "General," Chapter 5 on "Pyrometric Cones," Chapter 6 on "Liquid-in-Glass Thermometers," and Chapter 7 on "Bourdon Tube Thermometers" were published in pamphlet form in March, 1931.

[4] See pamphlet published in January, 1931.

[5] See pamphlet published in December, 1930.

[6] See pamphlet published in April, 1931.

[7] See pamphlet published in January, 1931.

[8] Chapter 1 of Part 21, on "Condenser Leakage Tests," was published in pamphlet form in November, 1928.

(*c*) Pitot- and impact-tube type
(*d*) Electric resistance or thermal type
(*e*) Area meters
(*f*) Weirs

5 Mixture Methods of Measurement
(*a*) Brine solution
(*b*) Brine velocity
(*c*) Color flow
(*d*) Addition of CO_2

6 Float or Drift Methods
(*a*) Float
(*b*) Screen

7 Pressure-Time Methods of Measurement (Water-hammer type)

III GASES—VOLUMETERS AND FLOWMETERS

1 Volumeters
(*a*) Gasometer bell type
(*b*) Bellows meters
(*c*) Wet rotary meters
(*d*) Dry rotary meters

2 Mechanical or Kinetic Meters
(*a*) Turbine meters
(*b*) Anemometers

3 Velocity-Volume Methods, Including Flowmeters
(*a*) Venturi tubes and nozzles
(*b*) Disk-orifice type
(*c*) Pitot- and impact-tube type
(*d*) Electric-resistance or thermal type
(*e*) Area meters

4 Mixture Methods
(*a*) Addition of CO_2

5 Pressure-Time (Fall of Pressure in Tank)

2 The apparatus and methods of measurements under any one of these divisions may be applicable to measurements in two or all three of the divisions. It is therefore desirable to classify these quantity-measuring devices on the basis of type of measuring device, since the alteration of the complete apparatus for solid, liquid, or gaseous materials usually alters a container or a constant for the device without affecting the nature of the device itself. This classification is given below.

CLASSIFICATION BY DEVICE OR METHOD

I—WEIGHING SCALES

1 Primary Element
(*a*) Lever type
(*b*) Spring type
(*c*) Pendulum type
(*d*) Hydrostatic-pressure type

2 Container
(*a*) Platform type for solids only
(*b*) Tank or hopper type for solids and liquids
(*c*) Conveyor type for solids only

3 Indication and Registration
(*a*) Dial types—for solids and liquids (type or punch marks)
(*b*) Tripper types—for solids and liquids (counter)
(*c*) Tilter types—for liquids only (counter)

II—VOLUMETERS

1 Tank Type—Liquid-Measuring Devices
(*a*) Trip-valve type
(*b*) Siphon type

2 Meter Type—Liquid-Measuring Devices
(*a*) Piston type
(*b*) Disk type
(*c*) Rotary type
(*d*) Turbine type

3 Gas Meters
(*a*) Bell type
(*b*) Bellows type
(*c*) Wet-rotary type
(*d*) Dry-rotary type

III—MECHANICAL OR KINETIC METERS—LIQUID OR GAS

1 Turbine Type (for liquids)
2 Anemometer Type (for liquids and gases)

IV—FLOW MEASUREMENT WITH NOZZLES AND VENTURI METERS

V—COMMERCIAL FLOWMETERS

VI—WEIRS

VII—MIXTURE METHODS OF MEASUREMENT

1 Brine Solution
2 Brine Velocity
3 Color Flow
4 Addition of CO_2

VIII—DRIFT-TYPE METHOD

IX—GIBSON METHOD (PRESSURE-TIME)

3 Under the second classification, the various measuring devices will be treated as *positive* or *inferential*, according to the method of measurement—whether by separation of successive isolated quantities, either weights or volumes, or by some indirect action or physical relationship of the material flowing which may be utilized to actuate an indicating or recording mechanism. *Positive* measuring devices usually operate by alternate filling and emptying of containers of known capacity. *Inferential* measuring devices operate, not by simple counting, but by inference from the action of the stream of flowing material on the measuring or recording element, through inertia, viscosity, specific heat, or some other property of the material that may act through known physical laws.

SECTION I—WEIGHING SCALES

1 PRIMARY ELEMENT

4 The common forms of scales generally utilize the lever, varying from the simple levers of the first order as in the "steelyards" and the chemical scales, up to the compound-lever combinations. Modern design has developed the hardened-steel knife-edge fulcrums of the better commercial scales into knife edges of agate for precision scales, while in large-capacity scales torsion bands and flexure plates have been introduced, eliminating friction except the molecular friction in the bands or plates, which is practically undetectable.

5 Of the other types of scale construction outlined, the spring-balance type is practically unused for test purposes. The pendulum type has been brought to a very high state of development in platform indicating scales for the rapid weighing of materials in industrial work. The hydrostatic-pressure type of scale has not been used to any extent in the commercial measurement of materials.

6 The ultimate purpose of scale design is to obtain *accuracy*, *constancy*, *sensitiveness*, and *speed*. *Accuracy* largely depends upon the correct proportioning of the lever and connections to the indicating or recording mechanism, and is obtained by accurate workmanship, accuracy of counterpoise weights and poises, proper design to reduce binds, accumulation of dirt, etc.

7 In the knife-edge types *accuracy* is also dependent upon the fact that a perfectly sharp knife edge cannot be produced to carry a load. The knife edge must have a bearing area sufficient to carry the load imposed without exceeding the elastic limit

of the material of which the knife edge is formed. Therefore it is necessary to make the knife edge actually a rounded surface, the radius of which increases with the loads to be carried. *Constancy* of measurement depends upon the strength and durability of the various parts of the scale mechanism, principally the knife edges and their bearing surfaces, corrosion, and dust accumulation. *Sensitiveness* depends upon the elimination of friction and low effort to move the indicating mechanism a definite amount. *Quick action* depends upon the mass of the beam or the sensitiveness of the indicating mechanism, and in automatic indicating scales upon an adequate damping system.

8 *Lever Type.* Scale mechanisms of this type are most commonly found employing the first order of lever as exemplified in the beam scales with the weight applied at one end of the lever and the resistance at the other.

9 In the many forms of platform scales, both stationary and portable, suspended scales, and track scales, a compound leverage is involved in transferring the weight force from the platform or track to the weighing beam. The design is usually in the form of a group of levers of the second order, which carry the weight between the fulcrum and the resistance, and sometimes two or more groups of such levers are involved. In certain classes of platform scales, particularly for trucking and railroad-track weighing, means are provided for lowering the lever system so that the platform drops on substantial fixed rests in order to relieve the knife edges from shock and wear in loading. In track and other large-capacity scale construction the use of flexure plates is a means of eliminating the friction and wear that occur in highly concentrated loadings on large-dimension knife edges.

10 The platform scale is the most commonly used type and it is typical of much of the larger weighing equipment, including vehicle scales and the smaller track scales. For quick-weighing purposes the beam of this type of scale can be fitted with an indicator dial as shown in Fig. 1. This general type of scale is employed in forms embodying hoppers, or bins, or tanks for weighing liquids.

11 The weighing *range* of lever balancing scales is practically unlimited for any type, being merely a function of strength of parts, but the degree of accuracy or sensitiveness that will result is to a large extent dependent upon limitation of the range of weighing capacity. As a general thing, scale makers must sacrifice considerable sensitiveness and accuracy in their commercial designs in order to insure a reasonable degree of constancy and reliability under ordinary usage.

12 The above remarks apply to knife-edge construction. The use of flexure plates makes it possible in commercial construction to get sensitiveness of a much higher order without sacrifice of sturdiness. The outstanding example of this form of construction is the Emery testing machine, in which accuracy of 1 part in 1,000,000 is obtainable. The accuracy of a similar capacity knife-edge device is about 1 part in 30,000. The flexure plate has not yet been widely employed for scales, but its possibilities are now beginning to be appreciated.

13 In the *installation* or preparation for test use of lever balancing scales, it is essential that the structure, including frame, levers, and beam supports, must be properly leveled and the working parts thereof adjusted and set so that:

(*a*) No moving parts touch or rub other parts except at points of support, at all working loads.

(*b*) All links, loops, and connecting rods are plumb.

(*c*) All knife edges are clean and rest centered and uniformly in their bearings.

(*d*) The check rods that center or guide the platform are in place, are horizontal, and are not binding.

(*e*) All parts are free from dirt accumulations which may occasion variable balance or binding.

14 The *precautions* to be taken in reading lever-balancing scales in order to avoid errors embrace the following:

(*a*) Make certain that scale beam is in perfect balance when counterpoise weights are removed and the movable poise on beam, if any, is at zero.

(*b*) See that beam and lever action are free and unrestricted by friction or faulty position of levers or fulcrum pivots. This is determined by tests with the movable poise at different parts of the beam scale by shifting it one or two notches in either direction from the balanced position; one notch should throw the beam from balanced position approximately one-fourth of its total movement between stops, whereas two notches should throw it entirely against either top or bottom stop. If movement or throw of beam is sluggish, examine the lever action for friction, faulty setting, dirt, or rust.

(*c*) Be sure that correct weights are used in balancing the beam, as checked, separate, or loose counterpoise weights may become mixed with unchecked weights from other scales.

(*d*) Avoid "parallax" in reading poise position or indicator.

(*e*) The scale beam should in all cases be balanced at the midpoint of throw or half-way between top and bottom stops; if the weight is taken with the beam above or below the midpoint of throw, it is likely to introduce an appreciable error.

(*f*) In scale beams with a card-printing attachment, the card should always be inserted for stamping *after* weighing is completed.

15 *Corrections.* As the lever-balancing type of scale is unaffected by either altitude, geographical location, or temperature, no corrections in readings of the scale beam are required except for mechanical errors as indicated under "Calibration." Any corrections that may be applied under such conditions will therefore be in the nature of a permanent correction.

16 The *calibration* of lever balancing scales is a factory or manufacturing problem involving careful checking of the accuracy of proportions of the leverages and comparison of the weighing performance against standard weights, the fundamental standards for which emanate from the U. S. Bureau of Standards. Tests of both accuracy and sensitiveness should be regularly made, particularly if the scales are used frequently, in order to make certain that they have not been damaged by rough usage, or their adjustments altered. If the scale is in continuous use for code testing, a test of the scale should be made not less than every two weeks. For shorter periods of code testing, the scale should be tested at the beginning and end of the test period. Such tests are usually made by applying weights in 50-lb. standard units or multiples thereof, in order to determine the weighing performance throughout the range of the scale. Standard test weights for this purpose are obtainable from scale manufacturers.

17 In preparing for a test of a lever balancing scale, it is important to make sure that all of the requirements for installation in Par. 13 are met. It is the purpose of a test to determine the following:

(*a*) Levers tested for uniformity of ratio of arms.

(*b*) Poise weights tested in sensitive balance against accurate test weights.

(*c*) Sensitiveness determined in connection with a graduated test.

(*d*) Graduated test of scale from balance at zero to full load, with standard test weights.

(*e*) Constancy tested by ability to repeat at or about full load.

(*f*) Accuracy of beam divisions with respect to fixed weight of poise.

(*g*) Accuracy of movable poise.

Engineering and Industrial Standardization

Electrical Standards Committee

AT THE regular quarterly meeting of the American Standards Association held in New York on June 4, 1931, the Association received and approved the proposed constitution for the Electrical Standards Committee. This constitution had been developed by a subcommittee of the Electrical Advisory Committee at the request of the American Institute of Electrical Engineers made in February, 1930. The members of the subcommittee are Messrs. F. B. Jewett, chairman, C. L. Collens, L. T. Robinson, and Alexander Maxwell.

With the development of the movement for national standards in the United States under the constitution and procedure of the American Standards Association, there has grown up a need and a desire for occasional general conferences of the several more or less distinctive groups of American industry. These conferences have in a number of cases crystallized into committees which have become advisors to their particular industry and to the A.S.A.

The national organizations interested in the formation of national safety codes were the first to organize in this way. Formed originally as the National Safety Code Committee, this group became the Safety Code Correlating Committee in 1922, and now consists of representatives of 16 organizations and government departments actively functioning in the safety field.

The mining industry was the next to respond to the urge for group action. In 1920, principally through the efforts of the American Mining Congress and the American Institute of Mining and Metallurgical Engineers, which have been most active in the development of mining standards and codes, this industry organized the Mining Standardization Correlating Committee. This group now numbers 12 organizations and government departments.

In November, 1925, The American Society of Mechanical Engineers issued a call for a general conference to consider the advisability of setting up a similar organization to serve the mechanical industries. Twenty-two organizations responded to the call for this first and subsequent conferences and in December, 1928, the Mechanical Standards Advisory Council was organized. Its membership has since grown to 24 societies and associations.

The constitution of the M.S.A.C. states that it is organized to serve as a general coordinating medium in the mechanical field within the scope of the constitution, by-laws, and rules of procedure of the A.S.A. It is proposed that the M.S.A.C. advise the A.S.A. on questions of policy and on the initiation, scope, and sponsorship for new projects. It will assist also in developing the personnel of sectional committees and follow up and expedite the work on standards. The decision by the A.S.A. on the proposal of the M.S.A.C. is still pending.

The most recent of these groups to be formed is the Electrical Standards Committee. Its constitution was completed and approved by the A.S.A. in June, 1931. The E.S.C. replaces the Electrical Advisory Committee which was originally formed in 1926. The new committee is to be composed of official representatives of eleven organizations which are considered to have interest in electrical standardization.

Its constitution, which in a sense is a charter, gives it functions and authority not granted to any of the other three corresponding correlating committees. The E.S.C. may determine questions of sponsorship, the scopes of projects, and the personnel of sectional committees; functions which the A.S.A. had formally reserved to its Standards Council. It may constitute itself the sponsor body for a given project and as the sectional committee under this sponsorship. The transmittal letter of the special committee that framed this constitution contains this significant paragraph:

> The fundamental feature of this plan is the unification of the process for formulating all of the standards of national scope affecting the electrical industry. To this end all of the types of procedure recognized by the A.S.A., and all of the powers appropriate for the formulation of standards, have been concentrated in one body. Ideally it might have been desirable that no sponsorships for electrical standards should exist outside of this body, but since practice and historical development, especially for the electrical codes, has identified some sponsors with their standards in a special degree, it is not proposed to disturb these relations, and ample provision has been made for their continuance. Since it is the definite desire of influential electrical bodies that review, approval, and promulgation shall be with the A.S.A., and that the making of standards shall be done by the proposed body or other suitable sponsors, this relation has been scrupulously preserved. It is provided that the Electrical Standards

NEW AMERICAN STANDARDS

The following standards were approved by the A.S.A. during the months of April 15–July 15, 1931:

Safety Code for Coal Mine Transportation (M15). (American Recommended Practice)

Sponsored by the American Mining Congress.

Safety Code for Elevators (A 17). (American Standard)

Sponsored by the Bureau of Standards, American Institute of Architects, and The American Society of Mechanical Engineers. Published by The American Society of Mechanical Engineers.

Specification for Zinc-Coated (Galvanized) Sheets (G8b1). (American Tentative Standard)

Sponsored by the American Society for Testing Materials. Published by the American Society for Testing Materials.

Specifications for Portland Cement (A1). (American Standard)

Sponsored by the American Society for Testing Materials. Published by the American Society for Testing Materials.

Dimensions of Wood Poles: Northern White Cedar (05b2); Western Red Cedar (05c2); Chestnut (05d2); and Southern Pine (05e2). (American Standards)

Sponsored by the Telephone Group. Published by the American Standards Association.

Specifications for Wood Poles: Northern White Cedar (05b1); Western Red Cedar (05c1); Chestnut (05d1); and Southern Pine (05e1). (American Tentative Standards)

Sponsored by the Telephone Group. Published by the American Standards Association.

Committee shall continue as an advisory committee to the A.S.A. and also that it shall, as a standards-making organization, have available for its use all of the various procedures set up by the A.S.A. for that purpose.

Local Representatives of A.S.A.

THE appointment of Monroe L. Patzig, secretary-treasurer of the Engineers Club of Des Moines and director of the Iowa Engineering Society, as representative in Iowa of the American Standards Association has been announced by the Association.

Beginning with the appointment of K. F. Treschow, Secretary, Engineers Society of Western Pennsylvania, in 1923, the American Standards Association has now designated eleven local representatives in as many cities. These representatives have agreed to serve as the contacts of the nation-wide standardization movement with the industries within the area which they serve. Through them general information relative to the activities of the A.S.A. may be obtained and copies of American standards may be ordered. A complete file of A.S.A. standards and bulletins will be maintained in the offices of these representatives.

The names and addresses of these representatives are listed below and it will be noted that in every case they are connected with a local engineering society, club, or industrial organization:

Pittsburgh, Pa. (1923), K. F. Treschow, Secretary, Engineers Society of Western Pennsylvania, William Penn Hotel.
Chicago, Ill. (1923), E. S. Nethercut, Secretary, Western Society of Engineers, 205 Wacker Drive.
Boston, Mass. (1923), E. O. Otis, Jr., Merchandising Adviser, Associated Industries of Massachusetts, 950 Park Square Building.
Seattle, Washington (1923), G. S. Wilson, Engineering Experiment Station, University of Washington.
Cleveland, Ohio (1925), C. R. Sabin, Secretary-Manager, Cleveland Engineering Society, Carnegie Hall, 1220 Huron Road.
Buffalo, N. Y. (1927), E. D. Strickland, Executive Secretary, Engineering Society of Buffalo, Hotel Statler.
Philadelphia, Pa. (1928), C. E. Billin, Secretary, Engineers Club of Philadelphia, 1317 Spruce Street.
Grand Rapids, Mich. (1929), B. Moll, Secretary, Grand Rapids Engineers Club, City Hall.
Rochester, N. Y. (1929), O. L. Angevine, Executive Secretary, Rochester Engineering Society, 115 East Avenue.
San Francisco, Calif. (1931), C. W. Whitney, Executive Secretary, Purchasing Agents' Association of Northern California, 433 California Street.
Des Moines, Iowa (1931), M. L. Patzig, Secretary-Treasurer, Engineers Club of Des Moines.

Correspondence

Development of the High-Speed Oil Engine in England

TO THE EDITOR:

The writer has read Mr. Chorlton's paper[1] with particularly keen interest, seeing that he was so closely associated with the author in his work in connection with high-speed compression-ignition engine development during the eight years the writer was head of the department responsible for engine design and research in the British Air Ministry.

It is of interest to note that Mr. Chorlton was the only oil-engine constructor with whom the question of the compression-ignition engine for aircraft was discussed by the writer in 1920 who held out any hopes that an aircraft compression-ignition engine was ever likely to be a possibility.

The twin-cylinder vee-type engine referred to by Mr. Chorlton was unquestionably an interesting example of high-speed oil-engine working, and it is a matter for regret that the promising preliminary tests on the engine were not carried right through, especially as regards supercharging. It has always been a matter of surprise to the writer that no report was ever prepared and published regarding this engine.

In the high-speed compression-ignition engine, as stated by Mr. Chorlton, the object is so to arrange matters that as nearly as possible complete combustion is secured—that is to say, either to take all the fuel to all the air, or bring all the air to all the fuel by an organized movement of the air. One would have expected that a combination of the two systems would have formed a good compromise, but so far the engines of really high efficiency which have been produced have incorporated either one or other of the schemes, and all efforts to combine the two have failed to give the best results.

Probably the most remarkable feature of the high-speed experiments carried out by Mr. Chorlton under the Air Ministry's supervision was that the unit fitted with his special form of injection gear gave good results almost from the very start—results which so far have not been excelled by any other engine.

From 1923 to 1926 the advantages gained by research work lay in the reduction of maximum pressures, for the same economy, from over 1000 lb. per sq. in.—as was the case at the commencement of the experiments—to round about 800 lb. per sq. in.

It was a great misfortune that, partly owing to the special requirements of the airship *R-101*, and partly owing to our ignorance of the troubles we were going to encounter, the eight-cylinder straight-line type of engine was chosen as the complete engine which was to make use of the single-cylinder experimental work. The long crankshaft, which had to be made of very generous dimensions in order to get away from torsional resonance periods, together with the inherently weak crankcase construction of the eight-cylinder-in-line engine, resulted, even after several years' work and heavy expenditure, in an engine which, for aircraft purposes, had an extremely poor weight/b.hp. ratio.

As regards Mr. Chorlton's statement concerning his advocacy of high compression ratios, it is unfortunate that it was not possible to experiment along these lines, but, owing to mechanical difficulties quite unconnected with compression ignition which were being experienced, and the fact that we were "working against the clock" to get the engines ready for the airship, we were not in a position to tackle any fresh problems not directly applicable to the production of the airship engines.

Mr. Chorlton draws attention to the necessity for research work to enable it to be possible accurately to predetermine a satisfactory combination of injection pump, injection nozzle, and combustion chamber without its being a matter of trial and error in every case. That this knowledge is still lacking is unfortunately a fact.

So far as the aircraft engine is concerned, the writer would also like to stress the importance of experimental work in connection with supercharging of the compression-ignition engine. Most of the work carried out so far in this direction has been of a somewhat tentative nature, and the writer is of the opinion that for the successful aircraft engine supercharging is an absolute essential in order to provide, by a moderate supercharge, a reasonable power/weight ratio at take-off when fuel economy is not of importance, and at the same time to enable ground-level power to be maintained at altitude with economy.

L. F. R. FELL.[2]

[1] Alan E. L. Chorlton, "Development of the High-Speed Oil Engine in England." Presented at the Fifth National Meeting of the A.S.M.E. Aeronautic Division, Baltimore, Md., May 12–14, 1931, and published in abridged form in MECHANICAL ENGINEERING, June, 1931, p. 421.

[2] Lieutenant-Colonel, R.A.F., 48 De Vere Gardens, Kensington, London, W.8, England.

MECHANICAL ENGINEERING

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A Single Court of Patent Appeals

ELSEWHERE in this issue is published, with a draft of a bill in the House of Representatives to establish a single United States Court of Patent Appeals, a brief article by Edwin J. Prindle describing the defects of the present system of patent appeals in this country and urging the adoption of the bill.

It is urged upon every one who has the good of his profession at heart to study Mr. Prindle's article and the proposed bill, and to offer constructive comment. In the light of a renewed campaign for a single court of patent appeals, a knowledge of the situation as it exists and an informed opinion backed by a majority of engineers is highly desirable. Engineers already owe a considerable debt to Mr. Prindle for his past constructive influence on questions relating to the Patent Office. They should give him whole-hearted and practical support. Comments and endorsements are solicited.

Progress in Aviation

LIKE THE Lindbergh flight across the Atlantic, the Post-Gatty flight around the world marks a milestone in the history of aviation. Aside from the amazing personal performance of the flier and navigator, the grueling test of making the flight across the Atlantic and Pacific and over two continents is a splendid testimony to the high degree of reliability already attained by both motors and planes. The fact that in their nine-day flight the fliers did no overhauling apart from the usual adjustments shows that not only the main elements of the apparatus, but, what is even more significant, the accessories, have already reached a stage where they are good for at least 15,000 miles without thorough re-servicing. If, therefore, planes fail under ordinary conditions of service in less than about two-thirds of this time, something must be at fault with maintenance, operation, or production.

Two other flights, less spectacular, of course, tend to support the same idea. One is the flight in a glider across the British Channel, and the other is the performance of a model plane at the recent Model Air Meet in Detroit, where one of the models stayed aloft for 29½ min., thus beating all previous records by a margin of about 400 per cent.

Both of these performances signify plainly the great progress made in the general science of aeronautics, without which neither could have been possible.

It is obvious that if a glider can be made to fly over such a distance as the British Channel under the disturbed air conditions prevailing there (the distance alone would not be even a record today), it will take only comparatively little power to give that glider full flying ability. The same applies to the little model flown in Detroit, and would indicate that for the same useful weight and speed we need less motor power, while the improvements in design and manufacture of the motors have definitely shown that, as compared with only a few years ago, we are getting a much greater output in horsepower-hours for the same weight of fuel.

Diesel-Engine Problems

DIESEL-ENGINE problems were discussed at the Fourth National Meeting of the A.S.M.E. Oil and Gas Power Division, June 23 to 26, 1931, at the University of Wisconsin, Madison, Wis. The Division has held its previous meetings at Pennsylvania State College, and this year's switch to the middle-west retained the university atmosphere that has been characteristic of its gatherings and so important in their success. The new mechanical-engineering building, dedicated on the day preceding the meeting and used on this occasion for the first time, provided excellent facilities, particularly for the numerous exhibits conveniently displayed in the same building that was used for the technical sessions, registration, and general headquarters.

The technical program opened with some papers dealing with research projects on oil sprays, combustion chambers, and flow of air through engine valves. Most of the papers were devoted to Diesel engines and Diesel-engine plants. Details were covered by papers on light-alloy pistons and rods, piston-packing problems, and heat-recovery apparatus. A new phase of the Division's interests was initiated in a paper on ship propulsion by oil engines. Reviews of development were touched upon by Louis Ford, who discussed double-acting Diesels, and by Col. Oliver F. Allen, who gave an illustrated talk covering his recent European experiences. An automatic Diesel plant was described by Edgar J. Kates. Mr. Kates' paper appeared in the July issue of MECHANICAL ENGINEERING. Two important committees of the Division, the Diesel Fuel Research Committee and the Diesel Power Committee, submitted reports.

The Diesel Fuel Research Committee has been engaged on a task that requires the balancing of three points of view in order that specifications of greatest value and fairness to all concerned may be arrived at. These points of view are those of the refiner who must provide the oil, the engine and accessory manufacturers who must modify their designs to take maximum advantage of a standard fuel, and the plant engineer who finds himself faced with the problem of maintaining continuous, reliable, and efficient operation. That these three groups are considering thoughtfully and helpfully the varied phases of the problem is significant of the modern attitude of engineers in providing the best solution to a perplexing problem.

The report of the Diesel Power Cost Committee presented complete power cost data covering 94 plants with 283 engines representing 161,583 installed horsepower. Both municipally owned and privately owned plants were included.

Costs of operation and maintenance and other plant statistics contain the elements of a powerful propaganda for the stimulation of the oil-engine industry. They must be painstakingly collected and accurately reported on a basis that makes comparison possible. They must be fair and reliable, as otherwise they are meaningless and likely to defeat the very purpose for which they are collected. The prestige and integrity of the Division are bound up in the quality of the report of the Diesel Power Committee.

Exhibits of Diesel engines, auxiliary apparatus, and accessories constituted an important feature of the meeting and were unusually interesting. They included a truck powered by a Hill Diesel engine, and the Diesel car built by C. L. Cummins that performed so creditably at the Indianapolis races. Demonstrations of both vehicles on the road were given.

Mention should also be made of the unusually interesting trip to the works of Fairbanks Morse & Co., at Beloit, Wis. Excellent arrangements had been made and an ample number of guides had been provided. Care had been exercised to insure that many interesting operations in the manufacture of Diesel engines would be seen during the brief period of the visit.

Two impressions of the Madison meeting stand out strongly in retrospect. First, the Diesel industry is highly competitive commercially and engineering discussions of its problems are not always free from this spirit. Second, a surprising number of fundamental problems still require intelligent solution. The A.S.M.E. Oil and Gas Power Division is serving an admirable purpose in providing a common meeting ground for engineers of the Diesel industry and in stimulating constructive and cooperative efforts in the solution of the industry's technical and economic problems.

S.P.E.E. at Purdue

SEVEN HUNDRED is an impressive number of persons to assemble in the interests of engineering education and this number marked a record attendance at the 39th Annual Meeting of the Society for the Promotion of Engineering Education at Purdue University, June 17 to 19, 1931.

Meetings of the S.P.E.E. are devoted roughly to the following program: conferences of divisional groups interested in specific subject matter, i.e., English, mechanics, machine design, etc.; general sessions for the discussion of topics of general interest; institutional meetings devoted to problems affecting the engineering colleges as educational institutions; and committee reports. In addition there is always a dinner and other social events. This year's meeting at Purdue followed the usual formula, the general sessions emphasizing the subject of research.

To the graduate engineer, whose college days are now little more than a pleasant memory, these meetings would be of greatest interest—as, indeed, we suspect they are to the majority of teachers—as an opportunity of greeting once more deans and professors and former colleagues now devoting themselves to education. Certainly it is an important function of such a gathering to renew, create, and cement friendships that bring satisfaction and inspiration. An interesting group is represented, earnest and intelligent, about as individually minded as can be found anywhere, and perhaps a trifle dogmatic at times because of the privilege of standing on the more conspicuous side of the recitation-room desk and auditorium lectern. The subjects discussed might seem academic to the practising engineer. If he were an employer of graduate engineers, or trying to decide on the education of a son or relative, he would find much to interest him—he would undoubtedly be impressed with the enthusiasm and seriousness of this group. He might, on the other hand, view the meeting and its discussions without sympathy or understanding.

No engineer can justify an indifferent attitude toward educational problems. It is not expected that he will have the mature and well-balanced point of view with regard to educational matters that one who has spent years in teaching may have acquired, and it is hoped that his criticisms of policies and methods, as well as curricula, will be constructive and based upon a thorough knowledge of the immediate condition of engineering education, rather than the inaccurate picture he has carried forward from his own undergraduate days, colored and distorted by his subsequent personal experiences. He must realize the tremendous importance of the work that is being carried on in educational institutions and have a proper interest in the influences that surround not only the future members of his profession, but the future citizens of his country. Engineering educators have been doing a pretty good job. They have subjected their methods and their ideals to a thorough-going analysis and they are constantly striving to improve their work and their product. The least that can be expected of the practitioner is his sympathetic support.

What every one is interested in—student, teacher, engineer, citizen—is the training that the youth receives for living as well as for making a living. In an ideal situation, living and making a living would be synonymous; in the actual case they are too frequently unjoined. Here it is where most of us fail, the student in evaluating what lies ahead of him, the teacher in not ministering to the spiritual and social, as well as the vocational, needs of his charges, and the engineer in partitioning the technological and humanitarian influences of his profession as though they were foreign to each other.

Here is a platform broad enough for engineering teacher and engineering practitioner alike to stand on—that each think of his job in terms of values and satisfactions, as contributing to personal and general cultural improvement as well as the vocational necessity of earning his daily bread. What we most admire and envy in the golden ages of the past is the power of integration that certain persons had and left evidences of, still visible to us and worthy of emulation. In modern society, so abundantly blessed with the products of science and engineering, the art of living ought even more easily to be coordinated with the art of making a living. To help young men to see this possibility and to effect this coordination should be a common obligation of teacher and engineer.

Applied Mechanics National Meeting

WITH Purdue University acting as host, the A.S.M.E. Applied Mechanics Division held its first national meeting June 15 to 17, 1931, at Lafayette, Ind. An attendance of approximately 200, drawn largely from the universities and the design and research departments of the larger manufacturing industries, indicated the success of the Division's venture in holding a national meeting. Representing as it does the maturity of a project within the activities of the A.S.M.E. by which the research and analytical worker in the field of mechanical design may be provided with an engineering subsociety devoted to and sympathetic with his interests, the Purdue meeting was one of unusual significance. It was plainly and convincingly demonstrated that the stratosphere of engineering thought within which the experimental and mathematical analyst works boasts a sufficient number of familiar spirits to guarantee a critical discussion of the elusive problems of natural phenomena confronting the designers of quite ordinary machinery. The spirit of scientific inquiry represented by the works of the engineers

comprising the Applied Mechanics Division is carrying on further refinements of the fundamentally sound design that in years past has not had to concern itself with certain features that intuition and empirical methods can attack only inadequately. What this means in greater reliability and safety, in ability to increase size, speed, and temperature conditions, to reduce waste of materials and the factor of ignorance, and to provide that confidence in methods that largely eliminates expensive failures of the design when embodied in a machine, is difficult to estimate.

The subject matter of the program was devoted to stress analysis, plasticity, vibration, and hydrodynamics, the last being discussed by the Division for the first time. A particularly commendable feature of the sessions was the manner in which the authors presented their rather specialized papers. None was read from manuscript, every author presenting his subject with due regard to the fact that an audience listening to a twenty-minute oral presentation does not have the opportunity for close study of detail possessed by a man who takes a printed paper into the quiet of his library or office. When authors of papers recognize the limitations surrounding their audiences and simplify their presentations by giving a logical oral explanation and summary as was done at Purdue, doing away with the hurriedly mumbled reading of the entire manuscript, more good will be accomplished.

The earnestness and interest displayed by authors and their audience, in spite of long sessions and the hot weather, were substantial evidence of the high quality of the Purdue meeting. Noteworthy too was the spirit that pervaded the entire group of sessions. The university setting was ideal for the professional point of view permeating the papers and discussions. Almost every paper had been inspired by some very practical need. Industry was largely interested in the results. Many of the authors were connected with industrial establishments, or had worked for industry. Yet the impression was gained that authors and audience were completely absorbed in the strictly professional, almost academic, aspects of their studies.

Industry should take great pride in the contributions to human knowledge that it is making through the work of such men as were represented at Purdue. While every industry had a specific and selfish interest at stake in the work reported, there can be no imprisoning of the knowledge gained so long as those who undertake the investigations are allowed to discuss them in public. The rewards for such work as was reported at Purdue are meager at best. The satisfaction that an engineer feels in being able to explain his work to his fellows, and in seeing it preserved for all time in engineering publications, is no small factor in these rewards. It is an inexpensive and additional recompense that industry can bestow upon her engineers to allow them the privilege of attaining a dignified publicity for their work. This by-product value should not be overlooked by industry, nor should its significance and importance be minimized.

It is natural, perhaps, to wonder to what extent the curricula of engineering colleges will be affected by growing interest in scientific and analytical methods in design problems. Only a minority of engineering students enter upon work in which the more advanced refinements in design find immediate application. Not every engineering student, indeed, perhaps, only a relatively small number, have the intellectual and temperamental qualifications to undertake such work. The plan of training every engineering-school graduate for a career in design and research is obviously impracticable. Yet in every graduate should be awakened an awareness to the powerful function that a scientific approach to industrial design problems may perform. The gifted student, suited by his temperament to the work of research and design, will find abundant opportunity for further education along the lines that best suit him for useful service after he has decided that his life should be dedicated to this kind of work. Other students, whose talents lead them into other fields of engineering, must be so imbued with a recognition of the potentialities of the scientific approach that they will make what use they can of it themselves, and be convinced of its adaptability to a majority of problems.

William Lawrence Saunders

1856–1931

W. L. SAUNDERS

AN OUTSTANDING engineer, William Lawrence Saunders, chairman of the board of directors of the Ingersoll-Rand Company, died on June 25, at Teneriffe, Canary Islands, while on a tour of the world. He was 74 years old, being born at Columbus, Ga., November 1, 1856. His career as an engineer extended over more than half a century with a record of distinguished public service in his later life. Perhaps the most important public position he occupied was that of chairman of the Naval Consulting Board, to which he was appointed by President Wilson in 1915.

As an inventor of devices now generally employed in certain branches of engineering, Mr. Saunders was well known. Chief among these was the apparatus for drilling rock under water and the Ingersoll track and bar channelers and gadders for quarrying dimension stone, marble, and limestone. He was interested particularly in the application of compressed air and for a time edited "*The Compressed Air Magazine*." He invented the radial axe system for coal mining and the method of pumping liquids by compressed air.

Mr. Saunders graduated from the University of Pennsylvania in 1876 with the degree of Bachelor of Science. For several years he was engaged in newspaper work in Philadelphia, and in 1878 he began his engineering career with the National Storage Company of Communipaw, N. J. Later he became engineer, vice-president, and president of the Ingersoll-Sergeant Drill Company and president of the Haesler Tool Company and the New York Imperial Tool Company. When the Ingersoll-Sergeant Company was succeeded by the Ingersoll-Rand Co., he became president and ultimately chairman of the board.

In December, 1926, Mr. Saunders announced through the American Society for the Control of Cancer that he would present a prize of $50,000 for the discovery of the nature of human cancer and an equal amount for the discovery of a positive cure. After two years he was convinced of the futility of the search and withdrew his offer.

Mr. Saunders was a former president, trustee, and member of the finance committee of the United Engineering Society, and a member of The American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Mining and Metallurgical Engineers, the Chamber of Commerce of the United States, the National Foreign Trade Council, the National Civic Federation, and was a Fellow of the American Geographical Society, the Academy of Political Science, and the American Academy of Political and Social Science. His club memberships included the Machinery, India House, Engineers, and University clubs.

Book Reviews and Library Notes

THE Library is a cooperative activity of the A.S.C.E., the A.I.M.E., the A.S.M.E., and the A.I.E.E. It is administered by the United Engineering Trustees, Inc., as a public reference library of engineering and the allied sciences. It contains 150,000 volumes and pamphlets and receives currently most of the important periodicals in its field. It is housed in the Engineering Societies Building, 29 West 39th St., New York, N. Y. In order to place its resources at the disposal of those unable to visit it in person, the Library is prepared to furnish lists of references on engineering subjects, copies of translations of articles, and similar assistance. Charges sufficient to cover the cost of this work are made.

The Library maintains a collection of modern technical books which may be rented by members residing in North America. A rental of five cents a day, plus transportation, is charged. In asking for information, letters should be made as definite as possible, so that the investigator may understand clearly what is desired.

Economic Control of Engineering and Manufacturing

ECONOMIC CONTROL OF ENGINEERING AND MANUFACTURING. By Frank L. Eidmann. McGraw-Hill Book Co., Inc., New York, 1931. Cloth, 6 × 9 in., 402 pp., illus., diagrams, tables, $4.

REVIEWED BY WILLIAM D. ENNIS[1]

SOME books constitute problems for the indexer. This is such a book. One library will class it with books on management. Another will call it a text on industrial engineering. Economics of engineering, and industrial engineering, seem to be topics which are related but different.

Industrial engineering may perhaps be defined by referring to the book under that title by Professor Shepard, although the book itself apparently contains no definition. That volume deals with *management*, and suggests principles of management. It stresses executive capacity. Its subject-matter verges on the psychological. It discusses personnel and wage systems, cost accounting (without formal accounting), the planning-routing-scheduling-dispatching sequence, and standards.

"Economics of Engineering," as a title, seems to be due to the late President Humphreys, but Professor Fisk produced a pioneer book in 1915: a book which is still perhaps the most rigorous of those in print. It is broad as well as arithmetical, dealing with such subjects as corporation organization and finance, and valuation. Fisk gives us a definition: "Engineering economics deals with those business problems which require more or less knowledge of engineering for their solution." The recent "Industrial Organization," by Professor Rubey is best classed in this field.

Professor Grant's book[2] is another and more representative example. Grant also provides a definition: Engineering economy (or any other kind) is "getting the most for your money." With both Fisk and Grant, the background is largely civil engineering. Civil engineers, as a group, have been more constantly preoccupied with money factors than some of the rest of us, and for a longer period. The dollar is a dominant element from the most preliminary stages of much of their work, and often a complex element, not to be juggled with by a layman.

Dean Kimball's "Industrial Economics" belongs rather in the field of industrial engineering than in that of economics of engineering; although it somewhat resists classification. It involves a brief presentation of traditional economics and a historical exposition of industrial development. Starting then with the division of labor, it describes standardization, personnel and its organization, Taylorism, and the measurement of management.

Professor Eidmann is preaching economics of engineering rather than industrial engineering. This he makes clear in his title and subject-matter. He presents material which has been used as the basis of a course in the School of Engineering at Princeton. His professes to be a book on management. So may (and do) profess books in either of the categories here differentiated. Eidmann describes the engineering and manufacturing processes from start to finish: from the phases of plant location and construction-cost estimates, through engineering for production and tool design, estimates of manufacturing cost, the selection, use, and handling of materials, the choice of equipment and its proper utilization and the conditions of its replacement, production planning with the questions of lot sizes, quality control, standardization and simplification—all the way to those of packaging and marketing. There is one "psychological" chapter, on personnel, and one on wage systems.

Now this sounds like industrial engineering; but Eidmann uses his topics as pegs on which to hang his economic (money, financial) calculations. It is dollar arithmetic that he is concerned with. He uses it in his engineering and manufacturing problems as they arise.

And this suggests what may prove to be a next desirable and necessary step forward. Eidmann makes the engineering foremost and the economics incidental. Fisk's definition suggests that it is the engineering which is incidental. Imagine a man studying the strength of beams and then digressing into a study of the calculus when it becomes necessary to set up an equation for the elastic curve. That is the way we are studying economics of engineering today. It might be better to recognize that there is a mathematics of economics, an arithmetic of the dollar; and that by mastering this we shall be better equipped to attack any of our engineering problems.

The current methods of treatment really involve rather sketchy applications of money factors. ("Assume interest at six per cent," etc.) The stress is on the engineering factors and complications. This is a good review of engineering, but is it what we are after? Why not study economics—business, dollars, finance, if these are better terms—applicable to engineering, manufacturing, the household, the family savings—applicable anywhere, in fact? We study (in some cases) engineering drawing, engineering physics, engineering chemistry, engineering economics. Why not study drawing, physics, chemistry, business?

[1] Alexander Crombie Humphreys Professor of Economics of Engineering, Stevens Institute of Technology, Hoboken, N. J. Mem. A.S.M.E.

[2] "Principles of Engineering Economy," by Eugene L. Grant. Reviewed in MECHANICAL ENGINEERING, November, 1930, p. 1014.

Heat-Drop Tables

REVIEWED BY F. DOLLIN[3]

THE REVISED HEAT-DROP TABLES (1931). Calculated by Dr. Herbert Moss from the revised data of the late Prof. H. L. Callendar. Edward Arnold & Co., London, 1931. Cloth, 8 × 11 in., 80 pp., 12s.6d.

IN RECENT years, and especially since the beginning of 1929, there has been great activity in several countries in the determination of the thermal properties of steam. By agreement among the various experimenters at work in Czechoslovakia, Germany, Great Britain, and the United States, a cooperative program has been established whereby results are exchanged and compared with the ultimate objective of establishing agreed values with agreed tolerances for a sufficient number of points to serve as a standard to which the final steam tables developed in any of the participating countries should conform. Much remains to be done before this goal is reached, and meanwhile progress in the art of power generation from steam plant is so rapid that the issue of tentative tables by various authorities has been necessary. In 1930, the A.S.M.E. issued the steam tables and Mollier diagram prepared by Professor Keenan, and now we have the 1931 heat-drop tables calculated by Dr. Moss from the revised formulas and data of the late Prof. H. L. Callendar for The British Electrical and Allied Industries Research Association.

Steam data can be presented in many different ways, the relative convenience and utility of which depend on the nature of the calculations to be made. There may be a tendency to feel that some form of greater general utility than a table of heat drops might have been chosen, but the importance of the adiabatic heat drop justifies the attention given to it, and in any case a book should be judged for what it is rather than for what it is not.

The tables under review are admirably arranged to serve their purpose as a working tool for the quick and accurate determination of the energy available by adiabatic expansion from any initial conditions to any exhaust vacuum from 27.0 to 29.5 in. Hg. Two facing pages are taken for each constant vacuum, and the figures are arranged in vertical columns of constant initial temperature and horizontal lines of constant initial pressure (gage). Tabulation by gage pressure and total temperature is very convenient, as these are the quantities directly measured in practice. Temperatures are given in steps of 25 deg. from 350 to 1000 deg. fahr.; saturation temperatures and corresponding heat drops are also given. The pressure intervals are naturally variable, tending to approximate to a geometrical ratio and running from 10 lb. per sq. in. between 100 and 400 lb. per sq. in. to 200 lb. per sq. in. above 2000 lb. per sq. in. The intervals of vacuum are tenths and quarters of an inch of mercury. The pages are thumb-indexed so that the book can be opened at once to the desired vacuum, and the cut corners of the pages are reinforced by linen backing. Clear printing and careful spacing enhance the value of this excellently arranged table. Two pages are devoted to low-pressure tables showing the heat drop for steam initially dry and saturated at pressures from 19 to 14 lb. per sq. in. absolute, down to exhaust vacua from 27.0 to 29.5 in. Hg.

The preface includes a list of the standards used in computing the tables and the constants to convert values into other systems of units. Rules for interpolation are also given, and it is important to note that for high initial pressures with small superheats it is necessary to interpolate for initial pressures and temperatures between the rate of change of heat drop. It is claimed that the accuracy of the tabulated values is such that any interpolated value should be correct within 0.1 B.t.u. of the directly calculated value.

A rather surprising omission is the absence of any statement of the equations from which the tables were calculated, although there is a reference to Callendar's paper in the Proceedings of the Institution of Mechanical Engineers, May, 1929, where the revised equations were given. A knowledge of the equations is not necessary in using the tables, but as a matter of record it would seem that they should be included.

Comparing the new Callendar heat drops with those obtained from the 1930 Keenan diagram, for an initial total temperature of 750 deg. fahr. and exhaust vacuum of 29 in., the Callendar heat drops are larger by an amount which tends to increase as the pressure rises but does not exceed 3.5 B.t.u. at any pressure up to 2000 lb. per sq. in. For a total temperature of 850 deg. fahr., the discrepancy is much smaller, not exceeding 2.5 B.t.u. even up to 3000 lb. per sq. in. and scarcely exceeding 1 B.t.u. over the range from 600 to 2400 lb. per sq. in. This must be regarded as a very good measure of agreement, and encourages the belief that when the various authorities prepare their final tables the differences between them will be narrowed down within very close limits.

[3] Experimental Division, South Philadelphia Works, Westinghouse Elec. & Mfg. Co., Philadelphia, Pa.

Books Received in the Library

ABFLUSS-UNTERSUCHUNGEN UND -BERECHNUNGEN FÜR UEBERFÄLLE AN SCHARFKANTIGEN WEHREN (Mitteilungen aus dem Gebiete des Wasserbaues und der Baugrundforschung, Heft 4). By C. Keutner. W. Ernst & Sohn, Berlin, 1931. Paper, 7 × 11 in., 27 pp., illus., diagrams, 4.20 r.m.

Gives the results of observations of flow phenomena over weirs in glass channels and of experiments to find equations for the flow which will be accurate in cases where the usual equations fail. Rehbock's formula is found correct for certain conditions; other formulas are developed for special cases.

AIR TRANSPORT OPERATION. By W. L. Smith. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 10 in., 316 pp., illus., diagrams, charts, maps, tables, $4.

Aims to present a detailed picture of present conditions in the regular operation of airplanes on scheduled flights and to indicate the probable line of future development of air transport. The factors that affect airplane operation are discussed in detail, and present possibilities of schedule maintenance are shown.

AIRCRAFT YEARBOOK, 1931. Edited by Aeronautical Chamber of Commerce. D. Van Nostrand Co., New York, 1931. Cloth, 6 × 9 in., 607 pp., illus., diagrams, charts, maps, tables, $6.

Reviews technical and commercial developments during the year. Describes the air lines in operation and the work of the army and navy, the activities of colleges, the changes in airplane design, legislation, etc. Drawings of all aircraft and engines in production are given, together with much statistical information.

ALLGEMEINE ERDÖLKUNDE FÜR INDUSTRIE U. HANDEL. By C. Koettnitz. W. Knapp, Halle (Saale), 1931. Paper, 7 × 9 in., 134 pp., table, 8.30 r.m.; bound, 9.80 r.m.

The occurrence, production, transportation, and properties of petroleum, methods of refining and testing, and the properties and uses of petroleum products are concisely presented. The various regulations governing the transportation of oil by German railroads are given in full.

BERECHNUNGSGRUNDLAGEN UND KONSTRUKTIVE AUSBILDUNG VON EINLAUFSPIRALE UND TURBINENSAUGROHR BEI NIEDERDRUCKANLAGEN. By H. Rohde. J. Springer, Berlin, 1931. Paper, 6 × 10 in., 112 pp., illus., diagrams, charts, tables, 11 r.m.

The design and construction of these important elements of a power plant are both hydraulic and mechanical problems, and the

present book is intended to throw light upon the structural and mechanical phases of the subject. The study is intended to assist in determining the most efficient forms, with due attention to both hydraulic and structural considerations.

BUSINESS ADRIFT. By W. B. Donham. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 165 pp., $2.50.

A thoughtful, important contribution upon the problems that threaten our future economic well-being. The author discusses the part that business men must play in meeting the needs of the American people, and offers a plan for the future which will meet changing business conditions intelligently.

DIE DEUTSCHE STEINKOHLENTEERINDUSTRIE UND IHRE WIRTSCHAFTLICHEN ZUSAMMENHÄNGE (Kohle, Koks, Teer, Bd. 26). By F. A. Heydenreich. W. Knapp, Halle (Saale), 1931. Paper, 7 × 9 in., 256 pp., diagrams, charts, tables, 23 r.m.

Although the chemical and industrial problems of the coal-tar industry have been the subject of much investigation, the economic questions have received less study. The present book is designed to make good the omission by providing a systematic account of the development of the coal-tar industry in Germany, its past and present organization, its markets, export trade, prices, etc. Statistics are given.

ELEMENTARY APPLIED AERODYNAMICS. By T. G. Whitlock. Clarendon Press, Oxford (Eng.); Oxford University Press, New York; 1931. Cloth, 5 × 8 in., 240 pp., illus., diagrams, charts, tables, $4.50.

An elementary textbook which calls for little mathematical knowledge except elementary algebra and trigonometry and the fundamental principles of mechanics. Within these mathematical limits the book aims to give a fairly complete account of the performance and theory of airfoils, airplane and airscrew performance, control and stability, scale effect, and airscrew theory.

ELEMENTS OF THERMODYNAMICS. By Ernest M. Fernald. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 329 pp., charts, diagrams, tables, $3.50.

Professor Fernald's aim is to give the student an adequate, flexible technique for dealing quantitatively with various situations, and sufficient data for meeting the simpler ones; together with clear ideas of the limitations that universal laws impose upon engineering practice, and of the conditions that practice must meet before finally perfected. The properties, processes, and cycles of steam and perfect gases, compressed air, refrigeration, evaporation, and flow through nozzles, etc., are discussed.

ENGINEERING MECHANICS. By F. L. Brown. John Wiley & Sons, New York, 1931. Cloth, 6 × 10 in., 477 pp., charts, diagrams, $4.

A textbook for students of engineering, covering the subjects usually included in undergraduate courses. A large number of illustrative and practical problems are given.

FACHAUSDRÜCKE DER SCHWEISSTECHNIK. Deutsch-Englisch-Russisch. V.D.I. Verlag, Berlin, 1931. Paper, 4 × 6 in., 31 pp., 2 r.m.

This little dictionary is intended to supplement the general engineering dictionaries by providing a list of the welding terms in general use, especially those of recent coinage. The book has been compiled by the Welding Committee of the Society of German Engineers, and is unusually successful in providing exact equivalents for the terms.

HARVARD BUSINESS REPORTS, Vol. 10. Cases on Marketing Airplanes. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 377 pp., tables, $5.

These thirty-six reports discuss actual situations and problems experienced by various companies in marketing airplanes, including coverage of markets, channels of distribution, prices, terms of sale, advertising, etc.

HEATING AND VENTILATION. Third edition. By J. R. Allen and J. H. Walker. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 9 in., 426 pp., illus., diagrams, charts, tables, $4.

Intended as a textbook for students of engineering and architecture, but will also be liked by engineers who wish a brief manual of design. The book has been thoroughly revised and is considerably enlarged. Material upon air conditioning and artificial cooling has been added.

HYDRAULICS FOR ENGINEERS. By R. W. Angus. Isaac Pitman & Sons, London and New York, 1931. Cloth, 6 × 9 in., 304 pp., illus., diagrams, charts, tables, $3.50.

The methods given in this textbook are those that the author has found successful during thirty years of experiment and practice, and in teaching hydraulic engineering. Difficult mathematics has been avoided. All discussion of hydrostatics is omitted, the matter treated being confined to the flow of water in pipes, orifices, weirs, and open channels; hydraulic turbines and centrifugal pumps; and non-uniform flow.

INDUSTRIELLES RECHNUNGSWESEN (AFIR-Mappe), Teil 1: Grundlagen. V.D.I. Verlag, Berlin, 1931. Paper, 9 × 12 in., diagrams, tables, 12 r.m.

The principles of industrial accounting are here presented in an unusual and interesting manner. Sixty-two graphic charts show the development of accounting processes from simple bookkeeping to cost accounting and other more complicated forms. A second part, upon control accounts, is to follow. The work is issued jointly by the Society of German Engineers and Society of German Machine Builders.

INDUSTRIEÖFEN, Vol. 2. Bau und Betrieb. By W. Trinks. V.D.I. Verlag, Berlin, 1931. Cloth, 6 × 9 in., 398 pp., illus., diagrams, charts, tables, 20 r.m.

This is the final volume of the German translation of a valuable book on industrial furnaces, the original of which is well-known to American engineers.

MACMILLAN TABLE SLIDE RULE. By J. P. Ballantine. Macmillan Co., New York, 1931. Paper, 9 × 11 in., tables, $0.50.

A set of four numerical tables and four slides, by means of which the arithmetical problems that arise in trigonometry and engineering may be solved without calculation. The charts answer the purpose of an ordinary slide rule. Three to four places can be read direct; five or more may be had by interpolation.

MATERIALS HANDBOOK. Second edition. By G. S. Brady. McGraw-Hill Book Co., New York, 1931. Leather, 4 × 7 in., 588 pp., charts, tables, $5.

Contains brief information upon the composition and properties of abrasives, brasses, bronzes, building materials, alloys, paints, chemicals, lubricants, and similar materials used in industry. The arrangement is alphabetic, and in addition a classified table of contents is provided. The book covers a wide range and will be a useful reference book for manufacturers, purchasing agents, and others having to select and distinguish materials.

MECHANICAL LABORATORY METHODS. Fourth edition. By J. C. Smallwood and F. W. Keator. D. Van Nostrand Co., New York, N. Y., 1931. Cloth, 6 × 10 in., 386 pp., illus., diagrams, charts, tables, $3.50.

Directions are given for testing and calibrating scales, calorimeters, brakes, fluid meters, and other instruments, for analyzing

fuels and determining their heat value, and for testing engines, boilers, pumps, refrigerating machinery, lubricants, and electrical machinery. The principles underlying the methods are given, and the directions are clear and concise. This edition has been revised and rearranged to conform with modern requirements.

Mitteilungen aus den Forschungsanstalten GHH-Konzern, Vol. 1, No. 3. Pp. 45–68. February, 1931. V.D.I. Verlag-Berlin. Paper, 8 × 12 in., 3 r.m.

Four investigations are reported: the effect of surface condition upon the durability of various steels; a critical investigation of the standard method for dynamic tests; recent advances in welding and cutting cast iron and cast steel; and the measurement of fluids in motion by means of nozzles.

Mitteilungen aus den Forschungsanstalten, GHH-Konzern, Vol. 1, No. 4, pp. 69–100, April, 1931. V.D.I. Verlag, Berlin. Paper, 8 × 12 in., charts, diagrams, tables, 4.50 r.m.

The three papers presented report the results of research work in large engineering works in Germany. Dr. Englert discusses the possibilities of the Loeffler boiler for pure power production, and shows that it is capable of considerable economies over the usual boilers. Dr. Klingenstein reports further investigations of the effects of composition and structure upon the resistance to wear of cast iron. Dr. Schilken considers the effect of various methods of grinding, lapping, and polishing upon the superficial structure of iron castings.

Mitteilungen der Deutschen Materialprüfungsanstalten No. 15. J. Springer, Berlin, 1931. Paper, 8 × 12 in., 73 pp., illus., diagrams, charts, tables, 13 r.m.

Contents: Bierett, G. Ein Beitrag zur Frage der Spannungsstörungen in Bolzenverbindungen. Experimentelle Untersuchung eines Augenstabes. Memmler, K. and Laute, K. Untersuchungen metallischer Baustoffe auf Schwingungsfestigkeit mit der Hochfrequenz-Zug-Druck-Maschine (Bauart Schenck). Stamer, J. Untersuchungen an zugfesten Anschlüssen im Holzbau.

These communications describe in detail recent investigations of structural elements at the German testing laboratory.

Mitteilungen des Hydraulischen Instituts der Technischen Hochschule, Munich, No. 4, 1931. By D. Thoma. R. Oldenbourg, Munich. Paper, 8 × 11 in., 104 pp., illus., diagrams, charts, tables, 7.20 r.m.

Seven reports upon experimental investigations of hydraulic problems recently made at the Institute. These include an investigation of flow in centrifugal pumps, a new instrument for measuring the velocity of turbulent water, the conversion of energy in draft tubes, hydraulic losses in pipe branches, an improved apparatus for testing the lubricating value of oils, the accuracy of current meters, and the phenomena that accompany sudden stoppage of centrifugal pumps.

"Opticks": or a Treatise of the Reflections, Refractions, Inflections and Colours of Light. By Sir I. Newton. McGraw-Hill Book Co., New York, 1931. Cloth, 5 × 8 in., 414 pp., diagrams, charts, tables, $2.50.

Newton's "Opticks" did not meet with great enthusiasm during his lifetime, and for generations was esteemed chiefly as a historical landmark displaying a marvelous combination of theoretical and experimental skill. Important recent discoveries have modified this opinion. The blending of corpuscular theory with wave theory which he suggests has interesting analogies with modern views and gives living interest to the work. This attractive reprint of the last edition revised by the author has a foreword by Professor Einstein and an introduction by Professor Whittaker.

Patent Law for Chemists, Engineers, and Executives. By F. H. Rhodes. McGraw-Hill Book Co., New York, 1931. Cloth, 6 × 8 in., 207 pp., $2.50.

This book, written for engineers and business men, discusses the questions of interest to men engaged in technical and administrative work. The law of patents, the requirements for a patentable invention, the rights that a United States patent confers, and similar general matters are explained and illustrated by citations from court decisions.

Royal Technical College Journal, Glasgow, January, 1931, vol. 2, part 3, pp. 371–566. Paper, 7 × 10 in., 10 s. 6 d.

Describes work in the fields of chemistry and engineering. Among the subjects investigated were the magnetostriction of overstrained materials, the transmission of heat in a fluid in turbulent motion, the rotating wheel with disk of constant stress ratio, pressure strains in non-circular drums, the influence of direct and shear stresses on the end constraints of curved bars, a standard of roughness for steam nozzles, torsional rigidity and web torque of crankshaft units and the effect of journal clearance, heat-transmission coefficients for superheated steam, fuel-pipe effects in mechanical-injection oil engines, the lubricating properties of mineral, vegetable, and fatty oils, the wave form of the mercury-arc power rectifier, and the radiant efficiency and heat distribution of electric fires.

Spanlose Formung der Metalle. (No. 16 der "Mitteilungen der deutschen Materialprüfungsanstalt.") By G. Sachs. J. Springer, Berlin, 1931. Cloth, 9 × 12 in., 127 pp., illus., diagrams, charts, tables, cloth, 28 r.m.

An account of four investigations carried out at the Kaiser Wilhelm Institut für Metallforschung. These include an experimental and theoretical examination of the deep stamping of sheet metal; experiments upon the properties of wire and the power consumed in drawing it; experiments to determine the power consumption and the phenomena of flow in extrusion presses; and an investigation of the effect of the shape of the tool upon the resistance of metals to indentation

Thomas' Register of American Manufacturers. Twenty-first edition. Thomas Publishing Co., New York, 1930–31. Cloth, 9 × 12 in., illus., $15.

The current issue of this well-known directory of manufacturers continues to be the most complete in its field. Firms are listed by products and also alphabetically. Credit ratings are given, and affiliates and subsidiaries are indicated. Lists of banks, commercial organizations, and trade papers are included, as well as a lengthy list of trade names.

Wesen, Ursachen und Verhütung der Kohlenstaubexplosionen und Kohlenstaubbrande. (Kohle, Koks, Teer, Vol. 27.) By H. Steinbrecher. W. Knapp, Halle (Saale), 1931. Paper, 6 × 9 in., 77 pp., diagrams, charts, tables, 6.80 r.m.

A concise review of our knowledge of the subject, based upon the investigations of the Lignite Research Institute of the Freiberg Mining Academy and others. The problem is discussed theoretically and practically.

Correction

On page 542 of the July issue of Mechanical Engineering, the equation $144 = h\rho$ should read $144p = h\rho$.

The publishers of "Natural Trigonometric Functions to Seven Decimal Places for Every Ten Seconds of Arc," by H. C. Ives, reviewed on page 557 of the July issue of Mechanical Engineering, notify us through the Engineering Societies Library that the price of $2.50 was given to us in error. The price of the book is $9.

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AIRPLANES

Noise Elimination. Noise, A. H. Davis. Aeroplane, vol. 40, no. 16, Apr. 22, 1931, pp. 725–726 and 728. Principles of noise measurement and comparison of various types of noises; analysis of noises of airplane engine lead to conclusion that exhausts, the clatter of engine itself, and noises of airscrew driven at moderate speed, are all of same order of noisiness, about 100 decibles. Before Roy. Aeronautical Soc.

Propellers. Care of the Detachable-Blade, Metal Propeller, F. W. Caldwell. Aviation, vol. 30, no. 6, June 1931, pp. 357–359, 2 figs. Aspects of care and servicing; checking propeller for balance; adjusting blades by means of protractor; inspection by etching; repair.

Controllable-Pitch Propeller, W. R. Turnbull. Roy. Aeronautical Soc.—Jl., vol. 35, no. 243, Mar. 1931, pp. 231–244, 4 figs. Advantages of controllable-pitch propeller and methods of hand control; brake control; hydraulic control; electrical control; graphs illustrate fixed-pitch propeller in level flight and in climb; pitch-fuel economy curves; speed-altitude curves for controllable-pitch propeller and supercharged and unsupercharged engine; weight data on various airplane-propeller blade materials.

Wings—Lift Distribution. Berechnung der Auftriebsverteilung beliebig geformter Fluegel (Calculation of Lift Distribution of Arbitrarily Shaped Wings), I. Lotz. Zeit. fuer Flugtechnik und Motorluftschiffahrt, vol. 22, no. 7, Apr. 14, 1931, pp. 189–195, 11 figs. Review of principal methods for calculating lift distribution; method of calculating lift distribution by means Fourier series for any profile and arbitrary incidence; application of method to air forces on control surfaces.

AIRSHIPS

Advantages in Long-Distance Transportation. Vorteile des Luftschiffs als Verkehrsmittel auf Groesstentfernungen (Advantages of Airships for Long-Distance Transportation), J. Breithaupt. Schiffbau, vol. 2, no. 10, May 15, 1931, pp. 238–242, 1 fig. General aspects; investigation of traffic conditions; routes between Cape Town-Berlin; Sydney-Berlin; Valparaiso-Berlin; San Francisco-Berlin; comparison between airplane and airship transportation; examples cited show advantages of airship transportation for long distances.

ALLOYS

Aluminum. See ALUMINUM ALLOYS; also DIE CASTINGS.

Chrome-Nickel. See CHROMIUM-NICKEL-IRON ALLOYS.

Copper-Zinc. See COPPER-ZINC ALLOYS.

ALUMINUM

Castings. Contribution à l'étude de la coulabilité (Study of Casting Properties of Metals), A. Courty. Revue de Métallurgie, vol. 28, nos. 3 and 4, Mar. 1931, pp. 169–182, and Apr., pp. 194–207, 46 figs. Applications to founding of aluminum, alpax, light aluminum alloys, and some tests on zinc; influence of pressure on casting properties; surface conditions.

Melting. Das Schmelzen von Aluminium in Tiegeloefen (Melting of Aluminum in Crucibles). Metallboerse, vol. 21, no. 39, May 16, 1931, pp. 915–916. Characteristic properties of aluminum and melting product which must be considered in selection of melting equipment and refractory materials required for melting and remelting aluminum and aluminum alloys.

Protective Coatings. The Surface Treatment of Aluminum and Its Alloys. Foundry Trade Jl., vol. 44, nos. 767 and 768, Apr. 30, 1931, pp. 301–303, and May 7, pp. 329–331. Question of protection from chemical effect, or corrosion, is by far greatest problem with which protective surface treatment is called upon to deal; available methods of surface treatment may be divided broadly into two main categories according as to whether they depend ultimately on chemical or mechanical means; different methods are discussed. Published as intelligence memorandum by British Aluminum Co.

Welding. The Jointing of Aluminium, U. Magani and C. Panseri. Metallurgist (Supp. to Engineer), Apr. 24, 1931, pp. 60–61. Authors divide jointing methods into two groups, corresponding to welding and soldering; fusion welding by oxy-hydrogen or oxyacetylene flame, electric welding, and hammer welding; principal attention is devoted to welding of aluminum containers or vessels of large size; solders of low melting point and those in which solder is alloy whose melting point is very little lower than that of material to be joined are dealt with at some length.

ALUMINUM ALLOYS

Machining. Nota su alcune questioni inerenti la lavorazione meccanica delle leghe leggere e dell'alluminio puro (Notes on Some Problems Pertaining to Machining of Light Alloys and Pure Aluminum), U. Magnani and C. Panseri. Metallurgia Italiana, vol. 23, no. 4, Apr. 1931, pp. 265–291, 72 figs. Survey of properties and characteristics of light alloys and aluminum in connection with principal machining operations including drilling, milling, turning, thread cutting, etc.; tables give data on feeds and speeds and sketches illustrate design of cutting tools. Bibliography.

AMMONIA CONDENSERS

Atmospheric. The Water-Cooled Atmospheric Condenser, J. H. Dannies. Ice and Cold Storage, vol. 34, no. 397, Apr. 1931, pp. 86–90, 2 figs. Factors entering into design of atmospheric condensers; every condenser performs two duties, namely: dissipation of heat from refrigerant to cooling medium in order to enforce condensing process, and dissipation of heat from cooling medium in order to maintain permanently dropping field of temperatures, which enables necessary flow of heat from refrigerant to cooling medium; mathematical analysis of condenser operation.

AUTOMOBILE ENGINES

Carburetors. Quelques idées nouvelles sur la carburation (Some New Ideas on Carburation), L. Durand. Technique Automobile et Aérienne, vol. 22, no. 153, 1931, pp. 55–57, 4 figs. Methods of controlling and improving mixture ratios and vaporization; sketches illustrate design providing for admission of preheated air at different places of carburetor system.

Franklin. Development of the Franklin Direct Air-Cooled Engine, E. S. Marks and C. T. Doman. Soc. Automotive Engrs.—Jl., vol. 28, no. 6, June 1931, pp. 669–676, 2 figs. Comparison of merits and short comings of air-cooled engines; Franklin valve-timing necessary for high speed and unobjectionable in combination with high compression. Discussion of paper previously indexed from Feb. 1931, issue of same Journal.

Fuel Injection. Versuche an einem niedrig verdichtenden Fahrzeugmotor bei kompressorloser Brennstoffeinspritzung von Fremdzuendung (Tests on Low Compression Automobile Engine With Compressorless Fuel Injection and Spark Ignition), Duell. Automobiltechnische Zeit., vol. 34, no. 13, May 10, 1931, pp. 299–302, 10 figs. Graphs illustrate test results obtained with 4-cylinder engine to determine optimum injection angle and ignition timing; effect of injection angle at full and part loads; relation between ignition timing, combustion velocity, output, and r.p.m. for compression ratio of 5.6.

Krupp. Der Gluehringmotor—ein neuer Kraftfahrzeugmotor fuer alle Brennstoffe (Glow-Ring Engine, a New Automotive Engine for All Kinds of Fuels), A. Lion. Foerdertechnik und Frachtverkehr, vol. 24, no. 7, Mar. 27, 1931, pp. 109–110, 3 figs. New Krupp engine has arrangement permitting changeover from gasoline to heavy oil without stopping engine.

AUTOMOBILES

Air Resistance. Wind Resistance Versus Car Performance, L. Schwitzer. Soc. Automotive Engrs.—Jl., vol. 28, no. 6, June 1931, pp. 631–635 and 668, 8 figs. European investigations regarding disturbance of airstream by bodies of various shapes are given and data are presented on power losses and power utilization in car designed by Rumpler in Germany and in two German racing cars; novel design features of streamlined cars.

Parking Machines. A New Type of Building—Vertical Parking Machine, H. D. James. Contract Rec., vol. 45, no. 20, May 20, 1931, pp. 583–585, 5 figs. Garage of unique design de-

veloped by H. D. James consulting engineer of Westinghouse Electric and Manufacturing Company; this machine consists of cradles, one for each car, supported between two endless chains which pass over sprocket wheels at top and bottom of travel; chains are driven by two electric motors, and by means of push-button control any cradle can be brought quickly to driveway level.

AUTOMOTIVE FUELS

Alcohol—Thermal Properties. Calorimetric Determinations of Thermal Properties of Methyl Alcohol, Ethyl Alcohol, and Benzene, E. F. Fiock, D. C. Ginnings, and W. B. Holton. U. S. Bur. Standards—Jl. Research, vol. 6, no. 5, May 1931, pp. 881–900, 2 figs. Method and calorimetric equipment previously used in determination of thermal properties of saturated water and steam were applied, without essential modification, in investigation of corresponding properties of methyl alcohol, ethyl alcohol, and benzene; determinations were made in range from 40 to 110 deg. cent.; skeleton table of more commonly used thermal properties of saturated liquids and vapors has been prepared.

AVIATION

Blind Flying. Les procèdès Loth pour le guidage des avions par ondes hertziennes (Loth Methods for Guiding of Airplanes by Means of Hertzian Waves), C. Dantin. Génie Civil, vol. 98, no. 19, May 9, 1931, pp. 473–475, 5 figs. Operating principles of Loth system, its disadvantages and merits according to Verdurand and Blancard; characteristics of Marrec filter.

B

BALANCING MACHINES

Dynamic. Dynamic Balancing Machine. Engineering, vol. 131, no. 3407, May 1, 1931, p. 591, 1 fig. New design of Olsen-Lundgren semi-automatic electric-spark machine, suitable for balancing small-crankshafts, such as those used for automobile engines.

BEARINGS

Design. Rapid Calculation of Bearing Loads Can Be Made With Simplified Forms, R. N. Janeway. Automotive Industries, vol. 64, nos. 22 and 23, May 30 and June 6, 1931, pp. 831–837, 4 figs. and 875–879, 9 figs. May 30: Method of determining bearing pressure, taking into consideration forces acting on each bearing due to inertia, centrifugal action and gas pressure; tables give necessary data for quick routine work, including standard form for determining bearing pressures in 8-cylinder engine with 5-bearing crankshaft; chart for determining counterweight effect on center bearing in 5-bearing 8-cylinder engine; mean crank pin loads in 6 and 12 cylinder engine. June 6: Derivations of formulas for inertia force; centifugal force; gas pressure; horizontal components of inertia and gas pressure; main bearing reaction factors; reduction of crankshaft throw to equivalent crankpin; correction of equivalent crankpin for eccentric center of gravity.

BELT DRIVES

Data on. Data on Belt Drives, R. J. Wilson. Am. Mach., vol. 74, no. 23, June 4, 1931, pp. 879–880, 1 chart. Interpretation of chart for design of single, double, triple, and four-ply belts on C. I. pulleys at 180 deg. belt contact; plotted for horsepower transmitted per inch width of belt at various velocities and including effects of centrifugal force; arc factor curves show comparative horsepower transmitted at two speeds at all arcs of belt contact up to 290 deg., with 180 deg. as base or ten-tenths of belt curve reading.

BINARY MIXTURES

Investigation of. Versuchsanlage zur Untersuchung von Zweisstoffgemischen (Experimental Plant for Investigation of Binary Mixtures), F. Bosnjakovic and J. Wucherer. Zeit. fuer die Gesamte Kaelte Industrie, vol. 38, no. 5, May 9, 1931, pp. 65–68, 4 figs. Plant was started and promoted by Merkels for study of ammonia-water mixtures, determination of relations between boiling pressure and temperature and composition of binary mixtures, also equilibrial composition of liquid and vapor phase, and specific volume of dry saturated steam; details of equipment installed and results obtained.

BLAST FURNACES

Practice. The Correlation of Blast Furnace Data, E. C. Evans, L. Reeve, and M. A. Vernon. Rolling Mill Jl., vol. 5, no. 5, May 1931, pp. 327–330. Mathematical expression of Evans and Bailey for quantitative expression of relationship existing between factors involved in blast-furnace operation has been examined in light of additional data and confirmed with modification, however that figure for carbon used other than at tuyeres has been calculated from gas analysis whenever possible. Before (Brit.) Inst. Metals.

BOILER FEEDWATER

[See FEEDWATER TREATMENT.]

BOILERS

High Pressure. Zahlenmaessiges vom Loefflerkessel (Performance Data of Loeffler Boilers), F. Englert. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 4, Apr. 1931, pp. 69–79, 9 figs. The possibilities of Loeffler high-pressure boiler are discussed; it is shown to possess considerable economies over the usual boiler types.

Trend of Boiler Design for Extra-High Pressures, C. C. Pounder. Mech. World, vol. 89, no. 2316, May 22, 1931, pp. 490–492, 4 figs. Most suitable form that boiler should take for very high pressures; alternative forms are considered and points mentioned which are urged by protagonists of newer forms against hitherto accepted types.

Manufacture. Gestaltung von gewellten Teilkammern fuer Dampfkessel (Design of Corrugated Sectional Chamber for Steam Boilers), M. Ulrich. V.D.I. Zeit., vol. 75, no. 21, May 23, 1931, pp. 654–656, 14 figs. Methods of producing sectional chambers with smooth corners in which fibers of materials follow along without being unduly stressed, developed by Vereinigte Stahlwerke, A.-G., Stahl- und Walzwerk Thyssen Muelheim-Ruhr, und Borsig, G.m.b.H., Berlin-Tegel.

The Production of High-Pressure Steam Boilers —I and II. Machy. (Lond.), vol. 38, nos. 971 and 972, May 21, 1931, pp. 225–230, and May 28, pp. 257–261, 23 figs. Manufacturing methods and equipment at plant of Babcock & Wilcox, Ltd., Renfrew; making cross-type marine water tube boiler arranged for land work; details of principal press and machining operations; riveting and caulking operations; trepanning tube holes.

Marine, High Pressure. The Cost Factor of High-Pressure Plants, C. S. Darling. Mar. Engr. and Motorship Bldr., vol. 54, no. 645, June 1931, pp. 225–229, 5 figs. Factors which marine engineer must consider before deciding upon particular pressure or temperature of steam production; major determinants in choice of steam cycle are: cost of fuel, cost of plant, size of plant, weight of plant and use factor; minor determinants; complexity of operation, ability to repair in normal workshops, interrelation with auxiliary requirements.

Natural-Gas-Fired. Natural Gas Proves Best Boiler Fuel, H. K. Blanning. Power, vol. 73, no. 20, May 19, 1931, pp. 776–778, 2 figs. Natural gas, replacing pulverized petroleum coke, shows 25 per cent reduction in total power-plant expense; relative fuel costs for equal B.t.u. were found to be 100 for natural gas, 118 for petroleum coke and 196 for oil; diagram of furnace as redesigned for natural gas and oil.

Operation. Etude des mouvements oscillatoires de la vapeur dans les chaudières (Study of Oscillatory Movement of Steam in Boilers), R. Selikin. Génie Civil, vol. 98, no. 18, May 2, 1931, pp. 456–457, 1 fig. Mathematical investigation of equilibrium conditions and methods of calculating principal factors contributing to this oscillation, such as dimensions of boiler, steam velocity, etc.

Plates—Cracking. Accelerated Cracking of Mild Steel (Boiler Plate) Under Repeated Bending, W. Rosenhain and A. J. Murphy. Iron and Coal Trades Rev., vol. 122, no. 3297, pp. 729–743, 20 figs.; see also Metallurgia, vol. 4, no. 19, May 1931, p. 18. Investigation of effect of exposure to mildly corrosive liquids upon endurance of mild-steel boiler plate under repeated plastic bending; test method; materials used; results; microscopic examination; results were obtained under conditions different from actual boiler operation, but may have some bearing on operation of hydraulic machinery and anchor chains. Before Iron and Steel Inst.

Identifying Causes of Boiler-Metal Cracking, F. G. Straub. Power, vol. 73, no. 21, May 26, 1931, pp. 809–812, 11 figs. During extensive researches on embrittlement, conducted at University of Illinois, in cooperation with Utilities Research Commission of Chicago, many samples of boiler metal were examined that had cracked from causes other than embrittlement; characteristic failures; microscopic analysis.

Pulverized-Coal-Fired. Un gènèrateur spècial pour la chauffe au charbon pulvèrisè (Special Generator for Pulverized Coil Firing), P. Scherer. Revue Gènèrale de L'Electricitè, vol. 29, no. 8, Feb. 21, 1931, pp. 309–313, 4 figs. Principles and characteristics of Lopulco boiler compared with other types; boiler of 590 sq. m. heating surface installed at Fuerst Hardenberg mine is taken as example and described in some detail; results of combustion tests.

Water Circulation. Dampferzeuger mit Zwangumlauf und mit awanglaeufiger Wasserverteilung (Steam Generators With Forced Circulation and Forced Water Distribution), T. Herpen. V.D.I. Zeit., vol. 75, no. 20, May 16, 1931, pp. 617–622, 21 figs. Characteristic features and advantages of La Mont design are illustrated by installation of Boston Consolidated Co. and Stahlwerk Duisburg-Meiderich; data on operating economy.

BRASS

Properties. The Static and Fatigue Properties of Brass, J. B. Kommers. Am. Soc. Testing Matls.—Advance Paper, no. 43, for mtg. June 22–26, 1931, 14 pp., 1 fig. Brass bars of three different compositions were obtained in form of cold-drawn $^{3}/_{4}$-in. rounds; these were tested after being fully annealed, after low-temperature anneal, and after being fully annealed and then subjected to various amounts of cold work in tension and compression; tests designed to determine especially effect of various kinds of cold work on static and fatigue properties; outstanding results.

BRASS-FOUNDRY PRACTICE

Cupola Melting. Cupola Melting of Brass, T. Mauland. Am. Foundrymen's Assn.—Preprint, no. 31–30, for mtg. May 4–7, 1931, 4 pp. Melting in cupola when fuel used is of high fixed carbon content; cupola used is small, lined down to 22$^{1}/_{2}$ in. inside diam. and is operated on low blast pressure and low air volume; lining used is monolithic silicon-carbide cement, with backing of firebrick and insulating brick; alloys melted are 85-5-5-5 and 80-10-10 composition; castings produced consist largely of carburetors and bushings and some of these, being light, are poured at temperature as high as 2300 deg. fahr.

Temperature Control. Measuring Temperatures of Molten Metal in the Brass Foundry, H. M. St. John. Am. Foundrymen's Assn.—Trans. and Bul., vol. 2, no. 5, May 1931, pp. 35–44, 2 figs. Need for controlling pouring temperature of nonferrous metals and application of control; types of pyrometers available together with precautions which must be taken in use and maintenance for trustworthy results. Paper given before Association Technique de Fonderie de France.

C

CARS

Brakes. Einfache Notbremse fuer Strassenbahnwagen (Simple Emergency Brake for Street Cars), von Lengerke. Verkehrstechnik, no. 19, May 8, 1931, p. 233, 5 figs. Oil-pressure brake installed in trailer on Saartal street railroad for application on steep grades, built on principle of Pieper brake.

Freight—Hopper. Pullman Builds All-Welded Hopper Cars for the C. G. W. Ry. Age, vol. 90, no. 19, May 9, 1931, pp. 902–904, 3 figs. With primary object o developing coal car to produce more revenue per pound of weight on rails, Chicago Great Western consented to have five units of its orders for 300 70-ton hopper cars placed with Pullman Car and Manufacturing Corporation in latter 1930, built to design proposed by car builder and embodying practically all-welded construction; general dimensions; method of construction employed.

Wheel Tires. Die Bearbeitung der Radreifen in der Werkstaette der Frankfurter Strassenbahn (Machining of Wheel Tires in Shops of Frankfurt a.M. Street Railways), G. Stephany. Verkehrstechnik, no. 20, May 15, 1931, pp. 243–245, 10 figs. Machining and control of tires and measuring instruments employed.

CAST IRON

High-Test. Praktische Gattierungsfragen (Practical Mixture Problems), H. Uhlitzsch. Giesserei, vol. 18, no. 22, May 29, 1931, pp. 433–437, 6 figs. Cast-iron diagram of Maurer and its extension; examination of F. B. Coyle's diagram based on Maurer's diagram and its extensions; mixture calculation is developed which takes into consideration fact that, to achieve certain quality, not one point, but field of diagram is available; calculation takes some time, but permits rapid change in mixture and simple control of change in composition of different mixture constituents.

Machinability. Ueber den Einfluss verschiedener Bearbeitungsverfahren auf das Gefuege in der Randzone von Gusseisen (Influence of Different Machining Processes on Surface Structure of Cast-Iron), W. Schilken. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 4, Apr. 1931, pp. 92–100, 43 figs, partly on supp. plates. Effect of various grinding, lapping and polishing methods is investigated.

Properties. Cast Iron: The Experience of the User. Metallurgist (Supp. to Engineer), May 29, 1931, pp. 79–80. Review of report issued by V.D.I., Berlin, 1930, on session of Committee on Engineering Materials, dealing with properties and tests of cast iron; at this conference, papers were presented in which observed properties of cast iron were reviewed and correlated, and methods of testing adopted to meet their special needs were outlined. Kuehnel reported results of coordination tests on cast irons of all engineering qualities which had been tested in course of routine inspection at testing department of German State Railways.

Wear. Weitere Untersuchungen ueber den Einfluss der Zusammensetzung und des Gefuegeaufbaus auf den Verschleiss von Gusseisen (Investigations of Influence of Composition and Structure on Wear of Cast Iron), T. Klingenstein. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 4, Apr. 1931, pp. 80–92, 12 figs. Increased phosphorus content is shown to have favorable effect on resistance to wear, especially when phosphorus addition exceeds 0.7 per cent; relation of nature of graphite separation to quantity of graphite separated was determined; tests were carried out on cast iron with pearlitic structure; influence of different alloying elements.

CHAIN DRIVES

Data on. A Modern Outlook on Chain Drive, J. H. Vose. Commonwealth Engr., vol. 18, no. 9, Apr. 1, 1931, pp. 320–327, 10 figs. Types of chain, i.e., bush roller and inverted tooth, latter often called silent chain; advantages of chain drive; chain selection; chain life; lubrication methods; adjustment of chains; limiting ratios of chain drives; standardization; conveyor chains; couplings, counter-weights and clutches.

CHAINS

Deformation. Some Experiments on the Strain-Hardening Induced in Iron and Steel by Certain Types of Mechanical Deformation, With Special Reference to D-Links for Colliery Tram Shackles, W. R. D. Jones and K. G. Lewis. S. Wales Inst. Engrs.—Proc., vol. 42, no. 1, Feb. 26, 1931, pp. 23–71, 33 figs.; see also Colliery Guardian, vol. 142, nos. 3664 and 3665, Mar. 20, 1931, pp. 1011 and (discussion) 1108–1109; also Iron and Coal Trades Rev., vol. 122, no. 3293, Apr. 10, 1931, p. 587. Paper treats chiefly of point that rivet holes and eye holes should be drilled and not punched; investigation of strain-hardening brought about by these processes and by drifting; amount and form of distribution of strain-hardening after stress.

Wrought-Iron. The Nature of Defective Laminations in Wrought-Iron Bars and Chain Links, H. J. Gough and A. J. Murphy. Engineering, vol. 131, no. 3409, May 15, 1931, p. 653, 4 figs. Experiments have been successful in elucidating one of causes of brittle failure in wrought-iron chains, and it is clear that every precaution should be taken in manufacturing stage to prevent incorporation of defective layers of type investigated; arising from results of present experiments, new test has been devised and inserted in recent British Standard Specification for Short-Link Crane Chain, for purpose of discovering presence of defective pilings.

CHIMNEYS

Wind Pressure. Wind Pressure on Large Chimneys, H. L. Dryden and G. C. Hill. Commercial Standards Monthly, vol. 7, no. 6, Dec. 1930, pp. 178–179, 4 figs. Wind-tunnel measurements; suction effects on chimneys; type of distribution changes with wind speed; model tests not reliable in this case; special stack built for outdoor measurements; power-plant stack used for measurements; tests indicate effect of length-diameter ratio.

CHROMIUM-NICKEL-IRON ALLOYS

High-Temperature Work. Some Alloys for Use at High Temperatures—III, C. H. M. Jenkins and H. J. Tapsell. Engineering, vol. 131, no. 3411, May 29, 1931, pp. 713–714 and 716, 4 figs. Complex iron-nickel-chromium alloys; investigations were carried out at National Physical Laboratory; objects of present work are to determine effect of additions of carbon and silicon to cast nickel-chromium-iron-tungsten alloy which appears to possess favorable resistance to creep at 800 deg. cent.; to determine effect of exposure of such alloys to service temperature of 800 deg. cent.; to account for phenomena met with in sections I and II. Before Iron and Steel Inst.

CONVEYORS

Belt—Design of. Determining the Trajectory of Material Discharged by a Belt Conveyor. Pit and Quarry, vol. 22, no. 4, May 20, 1931, pp. 47 and 59, 1 fig. In locating chute to receive discharge from belt conveyor, it is often desirable to take into account trajectory, or parabolic path, material will take under combined influences of gravity, speed of belt in feet per minute, and diameter of head pulley in inches; formulas worked out by engineering staff of Link-Belt Co. given in chart.

Pneumatic. Die Grenzen pneumatischer Foerderung (Limitations of Pneumatic Handling), R. Koeltzsch. Foerdertechnik und Frachtverkehr, vol. 24, no. 5, Feb. 27, 1931, pp. 71–75, 2 figs. Comparison of mechanical and pneumatic handling systems; influence of bulk weight, grain size, surface, hardness, and temperature of material to be conveyed on efficiency and economy; influence of drive.

Wear. Verschleiss und Verschleissverminderung an Foerdereinrichtungen (Reducing Wear in Conveyor Plants), E. Franke. Foerdertechnik und Frachtverkehr, vol. 24, no. 2, Jan. 16, 1931, pp. 17–21, 11 figs.; see also translation in Mech. Handling, vol. 18, no. 5, May 1931, pp. 150–152, 3 figs. Cause and treatment of wear in handling plants; particular attention is given to methods of reducing wear in wire ropes, chains and chain wheels; need for periodical inspection is also stressed.

COPPER-ZINC ALLOYS

Structure. Sur la structure des alliages cuivre-zinc (Structure of Copper-Zinc Alloys), W. Broniewski and J. Strasburger. Revue de Metallurgie, vol. 28, nos. 1 and 2, Jan. 1931, pp. 19–29, and Feb., pp. 79–84, 24 figs. Study of copper-zinc cast and heat-treated alloys based on diagrams of electric conductivity, coefficient of temperature of electric resistance, thermoelectric properties, electromotive force of dissolution, coefficient of expansion and hardness; results were verified by microscopic analysis and numerous photomicrographs are shown.

CRANES

Electric. A 250-Ton Electric Hammerhead Crane. Engineer, vol. 151, no. 3929, May 1, 1931, pp. 492–494, 24 figs., partly on p. 488 and supp. plate. Crane constructed by Sir William Arrol and Co. at Naval Yard of Vickers-Armstrong, consists of horizontal jib which can revolve on top of steel tower; trolley capable of handling working loads up to 250 tons travels along cantilever and auxiliary portal jib crane is also installed for handling smaller loads up to 20 tons.

Bemerkenswertes ueber Stueckgut-Windwerke elektrisch betriebener Verladeanlagen (Cranes for Bulk Materials of Electrically Operated Loading Plants), P. Frenzen. Foerdertechnik und Frachtverkehr, vol. 24, nos. 4 and 6, Feb. 13, 1931, pp. 54–57 and Mar. 13, pp. 86–88, 10 figs. General aspects; rope drum, and pulley diameter; grab and rope guide of cranes for bulk goods; design and operation of most practical types of hoists; device for regulating speed.

Locomotive. Large Breakdown Cranes. Engineer, vol. 151, no. 3933, May 29, 1931, pp. 604–605, 8 figs., partly on p. 600. Heaviest-duty breakdown crane built in Great Britain, is remarkable in that traveling axle load is only 17 tons, lead per ft. run over buffers 2.93 tons, and propping base is restricted to 17 ft.; it is of Stokes relieving-truck type, manufactured by Ransomes and Rapier.

Welded. Geschweisste Krane (Welded Cranes), H. Schmitt. V.D.I. Zeit., vol. 75, no. 21, May 23, 1931, pp. 652–653, 6 figs. Merits of various types of joints in construction of cranes, with structural steel illustrated by practical examples.

CUPOLAS

Moisture Control in. The Effect of Excessive Atmospheric Moisture in Cupola Blast, N. A. Moore. Foundry Trade Jl., vol. 44, no. 771, May 28, 1931, pp. 375–376 and 378, 1 fig. Effect of weather conditions on amount of water blown into cupola; variation in water blown into cupola; remedies used to reduce oxidation; effect of blast moisture; relation of oxygen content and fluidity; moisture-control system. Before Am. Foundrymen's Assn.

CUTTING TOOLS

Tungsten Carbide. Les métaux extra-durs pour outils (Extra Hard Metals for Tools), G. Ivanow. Revue Industrielle, vol. 61, no. 2263, June 1931, pp. 340–346, 17 figs. Metallurgical characteristics and performance of tungsten carbide and stellite cutting tools; sketches illustrate typical tool dimensions and shapes; heat treatment and care of tools.

D

DIE CASTINGS

Aluminum Alloys for. Effect of Composition on Aluminum-Base Die-Casting Alloys, D. L. Colwell. Am. Soc. Testing Matls.—Advance Paper, no. 22s, for mtg. June 22–26, 1931, 10 pp., 3 figs. Test of bar compositions; composition limits; chemical analysis; impact strengths of aluminum alloys; effect of composition on Charpy impact strength, and on tensile strength; data, accumulated by Committee B-6 on 12 aluminum-base die-casting alloys produced by five producers, include those from impact, tension and elongation test made by six cooperating laboratories.

Brass. Die Castings May Now Be Made of Brass, L. H. Morin. Iron Age, vol. 127, no. 19, May 7, 1931, pp. 1522–1524, 8 figs. Production methods and equipment of Doehler Die Casting Co., New York, with particular regard to requirements imposed by use of brass.

DIESEL-ELECTRIC POWER PLANTS

Governors. Test of Diesel Governor for A.-C. Drive, S. L. Kerr and W. M. Kauffmann. Power, vol. 73, no. 20, May 19, 1931, pp. 774–775, 3 figs. Study of characteristics necessary in governor to permit of parallel operation of generators; method of test; test results.

DIESEL ENGINES

Automotive. Compression-Ignition Automobile Engine, S. W. Nixon. Automobile Engr., vol. 21, no. 280, May 1931, pp. 196–202, 10 figs. Advantages of Diesel cycle in comparison with carburetor-type engine; disadvantages of compression-ignition engines; requirements of and some methods of fuel injection; design of representative types.

Design. Status of Compression-Ignition-Engine Research, E. T. Vincent. Soc. Automotive Engrs.—Jl., vol. 28, no. 6, June 1931, pp. 642–647 and (discussion) 647–652, 7 figs. Critical review of principal research work with particular regard to various types of injection, importance of turbulence and precombustion chamber types; graph illustrates effect of compression on combustion; effect of rate of fuel supply on combustion.

Fuel Injection. Effect of High Air Velocities on the Distribution and Penetration of a Fuel Spray, A. M. Rothrock. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 376, May 1931, 10 pp., 12 figs. By means of N.A.C.A. spray photography equipment high-speed moving pictures were taken of formation and development of fuel sprays, injected normal to and counter to air at velocities from 0 to 800 ft. per sec.; high air velocities as effective means of mixing fuel spray with air during injection, from automatic injection valves.

DYNAMIC SIMILITUDE

Conditions for. Ueber die Bedingungen fuer dynamische Aehnlichkeit (Conditions for Dynamic Similitude), W. Herrmann. V.D.I. Zeit., vol. 75, no. 20, May 16, 1931, pp. 611–616. Determination of number and form of similitude laws for various cases based on similitude theory of Newton, and establishment of necessary and sufficient conditions of dynamic similitude by means of general similitude principles of physics.

E

ELECTRIC FURNACES

Carburizing in. Electric Furnaces Used for Carburizing Locomotive Parts, W. S. Scott. Fuels and Furnaces, vol. 9, no. 6, June 1931, pp. 729–730, 2 figs. Results obtained with electric furnaces used in carburization of locomotive parts.

Temperature Regulators. Ein neuer Temperatur-Zeit-Regler (New Temperature-Time-Regulator), E. Gerold. Stahl und Eisen, vol. 51, no. 21, May 21, 1931, pp. 650–651, 3 figs. With new device developed by Siemens and Halske, it is possible to effect completely automatic regulation of electric heat-treating furnaces according to time-temperature curve; apparatus has been used for widely different purposes in research laboratory of Vereinigte Stahlwerke; with proper choice of heat capacity of furnace and of power supply, desired curves can be followed with high degree of accuracy.

ELECTRIC WELDING

See WELDING.

ELEVATORS

Electric, Two-Car. Two-Car Elevator. Professional Engr., vol. 16, no. 5, May 1931, pp. 18, 1 fig. Express and local service in same shaftway made possible with elevator of new type, built by Westinghouse Electric & Manufacturing Co., and placed in service at Company's main office building at East Pittsburgh, Pa.

F

FEEDWATER TREATMENT

Alkalinity and Embrittlement. Significance of Alkalinity in Embirittlement Studies—I and II, M. Hecht and D. S. McKinney. Power Plant Eng., vol. 35, nos. 11 and 12, June 1, 1931, pp. 602–604 and June 15, pp. 649–652, 5 figs. June 1: Indication of inadequacy of conventional alkalinity methods; futility of applying data derived from these methods to establish ratios for inhibiting embrittlement; development of method for correct evaluation and distribution of alkaline ions in water; ratio formula which considers all of inhabitants present in water. June 15: Derivation and graphical solution of ratio formula which considers all inhibitors which may be present.

Evaporators. Die Verdampfer und ihre Anwendung in der neutzeitlichen Speisewasserpflege (Evaporators and Their Use in Modern Feedwater Treatment), R. Klein. Waerme, vol. 54, no. 22, May 30, 1931, pp. 415–420, 10 figs. Most generally used types of evaporators for treatment of feedwater; field of application of evaporator is discussed with aid of practical examples.

Modern Plants for. Neuzeitliche Speisewasseranlagen (Modern Feedwater Treatment Plants), H. Balcke. Waerme, vol. 54, no. 22, May 30, 1931, pp. 431–432. It is claimed experiences gained in high-pressure plants, cannot be applied universally for low-pressure and hot-water boilers; advantages and disadvantages of different processes; author recommends Groeck process, making use of chromium compounds, which force carbonic acid from carbonates in proper concentration, dissolving these, and at same time protecting wall from corrosion.

Modern Processes. Die physikalisch-chemische Behandlung des Kesselinhaltes (Physico-Chemical Treatment of Boiler Feed), R. Stumper. Waerme, vol. 54, no. 22, May 30, 1931, pp. 397–402, 8 figs. Purposes of modern feedwater treatment; requirements of feedwater; different methods of treatment, including displacement of chemical equilibrium, colloidochemical, mechanical and electrochemical processes.

L'alimentation de la chaudière (Boiler Feedwater), P. Deullin. Chaleur et Industries, vol. 12, nos. 131 and 132, Mar. 1931, pp. 109–113, and Apr., pp. 178–188, 8 figs. Mar.: Study of feedwater treatment processes; natural water and theory of ions; classification of natural water; analysis and purification of water; different types of purifiers. Apr.: Distilled feedwater; chemical purification; choice of reagents; regenerative processes; permutit; neutralization with acids; electrolytic process; feedwater analyses.

Scale Analysis. Kesselspeisewasser und Kesselstein (Boiler Feedwater and Scale), G. Schmidt. Waerme, vol. 54, no. 22, May 30, 1931, pp. 403–408, 2 figs. Analysis of feedwater and steaming residue of inclined-tube boiler of Babcock type; quantitative data on reactions in boiler; comparison of feedwater analyses with sludge and scale analyses; chemical compounds of residues.

Sodium Aluminate Prevention of Silica Scale With Sodium Aluminate, C. H. Christman, J. A. Holmes, and H. Thompson. Indus. and Eng. Chem., vol. 23, no. 6, June 1931, pp. 637–646, 10 figs. Silica reduction in external softening may be improved by using sodium aluminate as coagulant; sufficient soluble alumina in boiler feedwater will effect silica precipitation in boilers as calcium or magnesium aluminosilicate; experimental boiler duplicating plant-operating conditions at high pressures is used for determination of reactions of silica in boiler waters; data from actual plant operation are included. Before Am. Chem. Soc.

Sodium Phosphate. Phosphate zur Wasserbehandlung im Kesselbetriebe (Phosphates for Boiler-Water Treatment), K. Morawe. Waerme, vol. 54, no. 22, May 30, 1931, pp. 412–414, 1 fig. Recommendations and reasons for use of phosphates, especially tri-sodium phosphate, for feedwater treatment, as dealt with in literature, are reviewed, after which reasons are given for not using these additions; it is believed that their use as substitute for lime and soda brings no advantages in spite of much higher costs; when used at all, phosphates should be added in very small quantities for secondary treatment of soft waters.

Praktische Erfahrungen mit der Kesselsteinverhuetung durch Trinatriumphosphat (Practical Experiences With Boiler-Scale Prevention by Tri-Sodium Phosphate Process), Koeppel. Waerme, vol. 54, no. 22, May 30, 1931, pp. 429–430, 2 figs. Experiences with vertical-tube boiler of 225 sq. m. heating surface and 15 atmos. operating pressure.

Softening. Der Haerteregler Aequivalenz fuer Kalk-Soda-Anlagen und Entkarbonisierungsanlagen ("Aequivalenz" Hardness Regulator for Lime-Soda and Carbon-Removal Plants), E. Haas. Waerme, vol. 54, no. 22, May 30, 1931, pp. 427–428, 1 fig. New device with which it is possible to regulate limewater flow according to hardness based on raw-water or pure-water analysis.

Zur Beschaffung von Aetznatron bzw. Natronlauge im Handel und zur Dosierung der Natronlauge in der Kesselspeisewasserpflege (Production of Caustic Soda and Soda Solution and Determination of Caustic-Soda Solution in Feedwater Treatment), A. Goldberg and E. Roettger. Waerme, vol. 54, no. 22, May 30, 1931, pp. 421–426. Softening reactions with caustic soda; valuation of commercial caustic-soda products; different products in solid form; softening with caustic-soda solution; apparatus for dissolving compact caustic soda.

FLOW OF FLUIDS

Measurement. Die Mengenmessung stroemender Medien mittels Stauringen (Measurement of Flow of Fluids by Means of Diaphragms), F. Loesser. Mitteilungen aus den Forschungsanstalten, vol. 1, no. 3, Feb. 1931, pp. 66–68, 1 fig. It is shown that, in spite of advances which have been made in field of flow measurement, it is not yet possible to determine accurately amount of gas flowing through diaphragm for all conditions.

FLOW OF GASES

Orifices. Note on Contraction Coefficients of Jets of Gas, E. Buckingham. U. S. Bur. Standards—Jl. Research, vol. 6, no. 5, May 1931, pp. 765–775. Jet of liquid from sharp-edged orifice contracts more than jet of gas because gas expands after leaving orifice; theoretical expressions for ratio of two contraction coefficients have hitherto been deduced from assumption that expansion is same in all directions; in present paper this is replaced by assumption that force exerted on upstream face of orifice plate on end of pipe depends only on static pressure and momentum of approaching stream.

FORGE-SHOP PRACTICE

Die Pressing. Verhalten der Metalle beim Warmpressverfahren (Behavior of Metals With Hot-Press Process). Metallboerse, vol. 21, nos. 31, 39 and 41, Apr. 18, 1931, pp. 724–725, May 16, pp. 916–917, and May 23, pp. 964–965, 15 figs. Development of use of presses for manufacture of pipe by hot-press process; investigation of two processes; review of research on flow of metal, and influence of pressure and temperature with different non-ferrous metals.

FORGINGS

Cleaning. Lead Film Protects Metal Under Scale, E. T. Youd. Metal Progress, vol. 19, no. 5, May 1931, pp. 56–59, 4 figs. Process for cleaning forgings discovered by Bullard Co., Bridgeport, Conn.; work is cathode; anodes are usually lead plates; small but effective amount of lead is in solution, and microscopically thin film is deposited on base metal itself immediately it becomes exposed.

FOUNDRY PRACTICE

Gating and Pouring Castings. The Gating and Pouring of Castings, E. V. Ronceray. Foundry Trade Jl., vol. 44, no. 771, May 28, 1931, pp. 369–371, 7 figs. Factors affecting shrinkage; principal types of gating; precautions necessary in gating and feeding; "Leonard effect;" three essential considerations in pouring; temperature of melting and pouring; duration of pouring; removing gas from molds; preventing shrinkage. Before Inst. Brit. Foundrymen.

G

GAGES

Automatic Gaging in Grinding. Selbsttaetiges Messen Waehrend des Schleifens (Automatic Gaging During Grinding), W. Grothkopp. Werkstattstechnik, vol. 25, no. 8, Apr. 15, 1931, pp. 201–205, 18 figs. Design and operation of various gages used in connection with grinding operation, which permit continuous observation of grinding progress until final dimensions are obtained.

Optical. Determining the Concentricity of Hollow Shafts, R. Leonhardt. Am. Mach., vol. 74, no. 24, June 11, 1931, pp. 894–895, 3 figs. Design and operation of cathetometer with twin telescopes; developed by Askania Works, Berlin, Germany; various thicknesses between inside and outside surface may be determined, and any misalignment of bore.

Strain, Magnetic. An Impact Strain Gage, C. A. Andree. Instruments, vol. 4, no. 5, May 1931, pp. 265–275, 7 figs. Design, theory, and calibration of gage for determining instantaneous variation in force, based on measurement of flux changes caused by variation of air gap.

GAS TURBINES

Natural-Gas. Turbines Driven by Natural Gas, C. H. Johnston. Power Plant Eng., vol. 35, no. 10, May 15, 1931, pp. 548–549, 2 figs. Steam turbines in absorption plant at Kettleman Hills field in Calif., fitted with special nozzles for utilization of natural gas at pressure of 275 lb. per sq. in.; successful operation of turbine installation.

GASOLINE ENGINES

Compression Ratio. The Cooperative Fuel-Research Committee Engine, H. L. Horning. Soc. Automotive Engrs.—Jl., vol. 28, no. 6, June 1931, pp. 637–641, 8 figs. Construction of original engine and table of dimensions of more important parts; refineries affect water-jacketing, condenser-coil location and accessibility of certain parts; features of redesigned engine with variable compression ratio.

GEAR-CUTTING MACHINES

Gear Planer, Large. 15-Ft. Sunderland Gear Planer. Engineering, vol. 131, no. 3411, May 29, 1931, pp. 699–701, 18 figs. partly on p. 704 and supp. plate. J. Parkinson and Son have completed largest machine of this type yet made, capable of cutting gears up to 15 ft. in diam. by 24 in. face, of either spur or double-helical tooth form, single-helical or spiral gears of similar diameter, and of 10-in. face at 30 deg. can also be cut.

GEARS

New Types. Neuere Verzahnungsarten und ihre Bewaehrung fuer die praktische Anwendung (New Gear Types and Their Reliability in Practical Application), A. Dorn. Maschinenbau, vol. 10, no. 9, May 7, 1931, pp. 317–320, 7 figs. Relative merits of different manufacturing methods for producing spur gears with straight and oblique teeth; advisability of grinding and hardening.

Noise Reduction. Quietness in Large Gears, J. W. Baugher, Jr. Am. Machy., vol. 74, no. 22, May 28, 1931, pp. 833–835, 5 figs. Method of reducing noise particularly by checking accuracy of gear cutting machine, and use of accurate gaging method; operation of machine for testing with great exactness, lead, pressure angle, tooth contour, and concentricity of diameters of hobs as large as 13 in. in diam. and 20 in. in length.

GUNS

Centrifugal Casting. Casting Guns by the Centrifugal Process, T. C. Dickson. Iron Age, vol. 127, no. 23, June 4, 1931, pp. 1816–1818. Casting equipment and procedure at Watertown Arsenal; advantages of centrifugal gun castings.

H

HEAT STORAGE

Electric Heating Units. Solid-Core Thermal-Storage Heating Units, L. G. A. Sims and K. R. Sturley. Engineering, vol. 131, pos. 3407 and 3410, May 1, 1931, pp. 561–564, and May 22, pp. 664–665, 23 figs. Systems heretofore employed in Great Britain are not convenient in cases where single small rooms and single offices have to be heated; for this purpose, unit type of heater is needed, having loading of few kilowatts only, capable of being installed without alteration to structure of building; results of experiments made in Electrical Engineering Department of University of Birmingham on one of best Continental heaters, and development of greatly improved design.

HEAT TRANSMISSION

Liquids in Viscous Flow. Heat Transfer to Liquids in Viscous Flow, C. G. Kirkbride and

W. L. McCabe. Indus. and Eng. Chem., vol. 23, no. 6, June 1931, pp. 625–631, 3 figs. New data are reported on transfer of heat into liquids flowing at velocities below isothermal critical velocity; these and other data are correlated by Nusselt-Groeber theory; experimental results are compared with theoretical calculations of Nusselt and Groeber.

HYDRAULIC ACCUMULATORS

Pressures in. Die Druck- und Arbeitsverluste in lufthydraulischen Akkumulatoren (Pressure and Working Losses in Air-Hydraulic Accumulators), R. Sackheim. Foerdertechnik und Frachtverkehr, vol. 24, nos. 2, 4 and 6, Jan. 16, 1931, pp. 23–26, Feb. 13, pp. 51–53, and Mar. 13, pp. 90–92, 30 figs. Testing equipment for investigation of pressure in hydraulic accumulators charged with compressed air; relation of pressure to different working conditions; pressure trend shown in entropy diagram; pipe-line losses; testing of accumulators by investigation of pressure.

HYDRAULIC LABORATORIES

Germany. Great German Hydraulic Laboratory, H. Rouse. Civil Eng. (N. Y.), vol. 1, no. 8, May 1931, pp. 715–720, 9 figs. Description of world's largest open-air hydraulic experiment station at Walchensee lake some 50 mi. from Munich; station layout; reading water elevation electrically; simultaneous measurements of flow through concrete canal by leading European and American methods, viz., Allen salt-velocity method, chemical, or titration method; current-meter method.

HYDROELECTRIC POWER DEVELOPMENTS

Ontario. Ontario "Hydro" Explains Power Policy. Can. Engr., vol. 60, no. 20, May 19, 1931, pp. 17–19. Formal statement explaining various features relating to present and future power demands and provision to meet them; progress re St. Lawrence power; power from Niagara; Ottawa river power; basis of power price.

HYDROELECTRIC POWER PLANTS

France. La centrale hydro-electrique du Bancairon de l'Energie Electrique du Littoral Mediterraneen (Hydroelectric Power Plant of Bancairon of l'Energie, Electrique du Littoral Méditerraneen), R. Gautheron. Revue d'Electricité et de Mécanique, no. 16, Mar.-Apr. 1931, pp. 26-XVI–46-XVI, 30 figs. partly on supp. plate. Description of roller weir and other headworks, of concrete construction; features of twin penstock, 1.40 to 1.75 m. dia., 850 m. long, designed for net head of 300 m.; plant has total power of 55,000 hp. installed in five turbo-generator sets of 11,000 hp. each; generated voltage at terminals is 10,000 volt; detailed description of plant and equipment is given.

Machinery. Contribution à l'élaboration d'un avant-projet d'usine hydroélectrique (Precalculation of Hydroelectric Plant Machinery), M. Mathieu. Arts et Mètiers, vol. 84, no. 128, May 1931, pp. 186–190, 3 figs. Methods of determining dimension, weight, and price of turbines and generators for given number of sets and given horsepower.

Pumped Storage. Pumped Storage for Regeneration, L. F. Harza. Power Plant Eng., vol. 35, no. 2, June 1, 1931, pp. 597–601, 4 figs. Methods of storing energy on large commercial scale; European practice of pumped storage power; pump-fed storage plants in Germany; design and operation features of several large plants in Germany; list of advantages and disadvantages of hydraulic storage; efficiency of conversion; economical capital expenditure limit.

I

INDUSTRIAL MANAGEMENT

Fundamentals. Management A B C's—3. Engineering and Research, H. Diemer. Factory and Indus. Mgmt., vol. 81, no. 6, June 1931, pp. 991–993, 2 figs. Three phases of product design; research work into fundamental principles, out of which grow new products and basic improvements in present products; practical development work which works these ideas into usable form and adapts them to customers' needs and manufacturing requirements; routine modifications of design types to meet customers' individual needs.

Measurement of. A Method of Measuring Productive Efficiency, R. E. Beswick. Mech. World, vol. 89, nos. 2312 and 2314, Apr. 24, 1931, pp. 396–398 and (discussion) May 8, 1931, pp. 444–447. Manner of securing practical measure of manufacturing efficiency in works producing wide variety of products in widely varying quantities. Before Instn. Production Engrs.

Production Planning. The Business Side of Tooling, H. C. Miller. Am. Mach., vol. 74, no. 24, June 11, 1931, pp. 891–893, 2 figs. Selection of new shop tooling with particular regard to mechanical and economic aspects; illustration of machine quotation record; condensed, systematic arrangement of vital information essential to rapid and accurate selection by comparison of equipment suitable to given manufacturing program.

Stores Control. Handling, Disposal, and Accounting for Obsolete and Sub-Standard Material. Nat. Elec. Light Assn.—Pub., no. 123, May 1931, 8 pp., 3 figs. Outline of methods developed in Supply Department to identify, classify, and to utilize or dispose of, inactive, obsolete, and sub-standard items of material and equipment that may have been acquired through purchase, or through returns to stock-room from operations, maintenance, and construction jobs, and from abandonments.

Time Study. Untersuchungen zur Bestimmung optimaler Handarbeitszeiten fuer die industrielle Fertigung (Investigations for Determining Optimum Time for Manual Work in Industrial Production), H. Klein. Maschinenbau, vol. 10, no. 9, May 7, 1931, pp. 309–316, 20 figs. Report on time study methods developed by Siemens-Schuckert Co., in connection with manufacture of electric motors, with particular regard to psychological factors involved; graphs and monograms for various machining and assembling operations.

INDUSTRIAL PLANTS

Inspection. Inpecting the Inspector, L. P. Marien. Am. Mach., vol. 74, no. 22, May 28, 1931, pp. 815–817, 3 figs. Inspection wage-incentive system on 7000 diversified parts that has increased production 156 per cent, reduced inspection costs 56 per cent and increased inspectors' wages 24 per cent at plant of DeLaval Separator Co., installed by Dyer Engineers, Inc., of Cleveland, Ohio.

INTERNAL-COMBUSTION ENGINES

Balance. Dynamic and Static Balancing of Internal-Combustion Engines, H. L. Hanawalt. Motive Power, vol. 2, no. 4, Apr. 1931, pp. 29 and 56–58. Study of vibration together with dynamic and static balancing; practical method of determining from amount of unbalance in crankshaft, flywheel or other rotating piece of machinery, degree of its unbalance. Before Soc. Automotive Engrs.

Cylinder Linings. Auswechselbare Zylinderlaufbuechsen (Exchangeable Cylinder Liners), E. Mahle. Deutsche Motor Zeit., vol. 8, no. 5, May 1931, pp. 166–170, and 172, 6 figs. Study of different causes of cylinder wear; measurements of Brinell hardness of wearing surface; development and advantages of wet and dry cylinder liners; experience with different lining materials particularly cast iron and steel.

Physics in Development of. Physics in Relation to the Development of the Internal-Combustion Engine, A. E. L. Chorlton. Engineering, vol. 131, nos. 3411 and 3412, May 29, 1931, pp. 711–712, and June 5, pp. 745–747, 7 figs. In history of development of engineering machines, development has rarely, if ever, been more assisted by physics than in case of internal-combustion engine, in which each important step forward has been undertaken only after exploration by physical means; history of development of internal-combustion engines from physical viewpoint, discussing various types. Before Inst. Physics.

[See also AUTOMOBILE ENGINES; DIESEL ENGINES; GASOLINE ENGINES.]

IRON AND STEEL

Magnetic Testing. Relation Between Magnetic Properties, Impact Strength, and Hardness, H. Styri. Am. Soc. Testing Matls.—Advance Paper, no. 33, for mtg. June 22–26, 1931, 12 pp., 4 figs. Results of investigation of subcommittee of Society's Committee A-8 on magnetic analysis, formed to investigate relationship between magnetic testing and impact strength and hardness; results are summarized in graphical form.

IRON AND STEEL PLANTS

Great Britain. The Melting Shop of the Appleby Iron Company, Limited, A. Robinson. Engineering, vol. 131, nos. 3408 and 3410, May 8, 1931, pp. 616–618, and May 22, pp. 686–688, 8 figs.; see also discussion in no. 3409, May 15, pp. 650–651. Process is carried on in large tilting furnaces with semi-active mixer; main building houses three 250-ton and one 300-ton tilting furnaces and 500-ton mixer placed centrally between them; 75-ton blast-furnace-iron ladles are of horizontal cylindrical mixer type, running on special trucks; gas-making plant includes nine producers with small overhead bunkers; steel-making and casting practice. Before Iron and Steel Inst.

Production Control. Production Economy in Iron and Steel Works, O. Cromberg. Iron and Steel Trades Rev., vol. 122, no. 3297, May 8, 1931, pp. 736–739, 1 fig.; see also Metallurgia, vol. 4, no. 19, May, 1931, p. 17. Scientific organization of manufacturing; adjustment of German industry to post-war economic conditions; time study records; accounting of daily position of orders and stock; records of rolling-mill output; output diagram, indicating manhours per unit of production; curves indicate good results achieved by continuous supervision of daily output of work. Before Iron and Steel Inst.

L

LATHES

Design. Geometric Progression in Machine Tool Speeds, J. Decker. Am. Mach., vol. 74, no. 19, May 7, 1931, pp. 721–724, 3 figs. National Machine Tool Builders' Association's recommendations for machine-tool standardization; advantages of system of standardized ratios and speed worked out by G. Schlesinger of Technical University of Berlin.

LOCOMOTIVES

Articulated, Coal Bunker for. Beyer-Peacock Self-Trimming Coal Bunker. Locomotive, vol. 37, no. 464, Apr. 15, 1931, pp. 119–121, 3 figs. Design and operating characteristics of self-trimming coal bunkers fitted to Beyer-Garratt Locomotives in service on L. M. and S. Ry.

Design. On the Calculation of the Draw-Bar Pull of Steam Locomotives—Part II, R. Nakamura. Japanese Gov. Railways—Bul., vol. 19, no. 17, Apr. 25, 1931, 29 pp. Relations between steam consumption and horsepower developed as result of tests on steam locomotives in oil-locomotive testing plant, new formulas have proved recommendable for i.hp. and tractive effort at driving wheel.

Diesel. Die Wirtschaftlichkeit von Dieselokomotiven (Economy of Diesel Locomotives), J. Geiger. Organ fuer die Fortschritte des Eisenbahnwesens, vol. 86, no. 7, Apr. 1, 1931, pp. 171–176, 2 figs. Comparison of economy of Diesel locomotive operations for different types of train service with steam engine; report on practical experiences in various countries; data on capital investment and amortization for Diesel locomotives and repair shops.

Freight. A 2-10-4 Type Locomotive for the Atchison, Topeka, and Santa Fe Railway. Baldwin Locomotives, vol. 9, no. 4, Apr. 1931, pp. 45–48, 8 figs. Design and constructional developments in Santa Fe locomotives; specification table of ten-coupled locomotives dating from 1902.

Motor Type Locomotive—Lehigh Valley Ry. Jl., vol. 37, no. 5, May 1931, p. 17, 1 fig. Design features of streamline high-speed locomotive; usual piping almost entirely missing; cylinders 26 by 32 in.; driving wheels 70 in.; boiler pressure 255 lb. per sq. in.; tractive power with booster 85,060 lb.; engine wheel-base 47 ft. 7 in.; total loaded weight 422,000 lb.

High-Pressure. Canadian Pacific Railway Multi-Pressure Locomotive. Engineer, vol. 151, no. 3932, May 22, 1931, p. 580, 1 fig. Locomotive of "Schmidt" two-pressure type built at Angus Works of Canadian Pacific Railway Co.; engine "No. 8000," is intended for freight and passenger traffic on Rockies, and is far largest of its type in existence; driving wheels are 63 in. in diam. and there are two outside 24- by 30-in. cylinders taking steam at 250 lb. and one 15½- by 28-in. cylinder inside for steam at 850 lb. per sq. in.

Internal-Combustion. Motorkleinlokomotiven bei der Deutschen Reichsbahn-Gesellschaft (Small Internal-Combustion Locomotives of German Government Railroad), F. Witte and O. Stamm. Verkehrstechnik, no. 14, Apr. 3, 1931, pp. 177–178, 6 figs. Details of 40-hp. locomotive with gasoline and with Diesel engines; automatic car coupling; 50-hp. carburetor locomotive with electric starter.

Passenger. Rebuilt "Pacific" Locomotive, Paris-Orleans Railway. Ry. Gaz., vol. 54, no. 19, May 8, 1931, pp. 705–706, 2 figs. Modifications of boiler and cylinders of P.-O. standard "Pacifics" have increased power and efficiency; cylinders 16½ by 25 by 25½ in.; driving wheels 6 ft. 3 in.; boiler pressure 235 lb. per sq. in.; 3000 lb. maximum cylinder horsepower; engine weight, 99 tons.

Three-Cylinder. C.P.R. Completes Double-Pressure Three-Cylinder Locomotive. Ry. Age, vol. 90, no. 19, May 9, 1931, pp. 913–914, 1 fig. Oil burner built with Schmidt method of indirect steam generation; 2-10-4 type with tractive force of 90,000 lb.; cylinders, high pressure 15½ by 28 in. with 850 lb. pressure; low pressure, 24 by 30 in. using 250 lb. per sq. in.; total weight 485,000 lb.; driving wheels 63 in.

LUBRICANTS

Testing. Alterabilité des huiles de graissage (Stability of Lubricating Oils), J. Dintilhaz. La Pratique Automobile, vol. 27, nos. 582 and 583, May 1, 1931, pp. 16,549–16,550 and 16,552, May 15, pp. 16,580 and 16,582. Design and operation of machine system Yacco consisting essentially of two cylinders, smaller turning inside larger, for investigating break-down resistance of lubricants, with particular regard to tendency of forming gummy deposits; stability of lubricating oils under operating conditions as determined by flashpoint, Conradson test, formation of gummy residues and cracking.

LUBRICATING OIL

Synthetic. Chemistry Makes Synthetic Lubricant, F. W. Sullivan, V. Voorhees, A. W. Neeley, and R. V. Shankland. World Petroleum, vol. 2, no. 5, May 1931, p. 336. Study of many natural oils indicated that ideal lubricants would be made up of hydrocarbons having in their molecules approximately two hydrogen atoms for each carbon atom; after investigation of many raw materials for synthetic production, paraffin wax was selected; after being cracked under certain conditions it yields olefines needed, and polymerization of these produces superior grades of lubricating oils. Before Am. Chem. Soc.

Synthetic Lubricating Oils, F. W. Sullivan, Jr., V. Voorhees, A. W. Neeley, and R. V. Shankland. Indus. and Eng. Chem., vol. 23, no. 6, June 1931, pp. 604–611, 2 figs. Relation between chemical constitution and physical properties; systematic investigation of lubricating oils made by polymerization of olefins with aluminum chloride; commercial process has been developed for production of oils by this means; products are well suited for uses where constancy of viscosity with varying temperature or high oxidation stability is required. Bibliography.

LUBRICATION

Research in. Modern Lubrication Studies, A. E. Flowers. Power, vol. 73, no. 21, May 26, 1931, pp. 828–829, 2 figs. Modern high-speed heavy-duty power machinery so dependent upon lubrication that almost every user confronted with problems involving maintenance of journal oil film; outline of research work and equipment.

M

MACHINE TOOLS

Obsolescence. Alte Werkzeugmaschinen Bringen Verlust (Old Machine Tools Cause Losses), O. Kienzle. Werkstattstechnik, vol. 25, no. 8, Apr. 15, 1931, pp. 206–207. Comparison of three formulas used by Koch & Kienzle, Warner, Swasey & Co. and SKF, respectively, for correlating capital investment, depreciation, and savings by improved machinery.

Portable. Neuere ortsbewegliche Werkzeugmaschinen zum Nacharbeiten fest eingebauter Maschinenteile (Modern Locomobile Machine Tools for Machining Non-Removable Parts of Machinery), S. Weil. Maschinenbau, vol. 10, no. 8, Apr. 16, 1931, pp. 279–281, 10 figs. Design and operation of various types of machine tools used in railroad repair shops, rolling mills, and for grinding of joints of street car rails; design of portable boring and milling machine.

Work-Holding Devices. The New Alloys and Machine-Tool Design. F. W. Shaw. Metallurgia, vol. 3, no. 18, and vol. 4, no. 19, Apr. 1931, pp. 209–212, and May 23–25, 14 figs. Apr.: Hand-actuated work-holding devices; examination of problems that confront designer of modern work-holding devices; desirable features. May: Power-actuated work-holding devices; discussion of means for reducing chucking-fatigue factor; principles and construction of mechanical, magnetic, hydraulic, and pneumatic work-holding devices.

MACHINERY

Dynamical Analysis of. Dynamical Analysis of Machines, R. Eksergian. Franklin Inst.—Jl., vol. 211, no. 5, May 1931, pp. 627–652. Oscillations of linkage mechanism; dynamical equations for system of vibrating disks; relations of elastic coefficients; energy method in shaft analysis; inertia coefficients and velocity ratios. Bibliography.

MALLEABLE-IRON CASTINGS

Properties. The Life of Malleable Cast Iron, E. K. Widin and N. G. Girschowitsch. Foundry Trade Jl., vol. 44, no. 771, May 28, 1931, p. 374, 2 figs. Results of investigation of molded spiral with cross-section of 8 by 12.5 mm.; total length of about 1800 mm., and outer diam. of 280 mm.; in preliminary experiments it was ascertained which molding method gave least differences in lengths of several spirals cast under identical conditions; casting temperature; molding sands; dimensions of runner and of casting.

MATERIALS HANDLING

Industrial Plants. Materials Handling in Quantity Production Shops, N. H. Preble. Iron Age, vol. 127, no. 23, June 4, 1931, pp. 1806–1809 and 1858, 4 figs. Survey of means and ends of production handling in various industrial plants including Timken Detroit plant and Studebaker plant; use of conveyors and industrial trucks.

Lifting Devices. Enquete sur l'état actuel de la technique des Appareils de Levage et de Manutention mécanique (Investigation of Present State of Devices for Mechanical Lifting and Handling), M. Pelou, Science et Industrie, vol. 15, no. 207 and 208, Apr. 1931, pp. 197–206, and May, pp. 230–236, 34 figs. Derricking devices; comparative and recapitulatory table of different systems; study of winches and winches with two drums for grab-buckets; orientation and traversing devices; different types of cranes; typical apparatus for each type; examples of special devices; rotary fixed cranes, workshop, type traveling cranes, and derrick wagon cranes.

Stacking Machines. An Efficient Stacking System. Mech. Handling, vol. 18, no. 6, June 1931, p. 195, 1 fig. "Phec" Stacker, supplied by Paterson Hughes Engineering Co.; outstanding features are: "straight-through" passage of article, thus entirely dispensing with pivoting and slewing, centrally supported elevating cradle, automatic ejection of load, and return of cradle to loading position.

METALS

Elastic Hysteresis. Die Werkstoffdaempfung bei Dreh- und Beigeschwingungsbeanspruchung (Elastic Hysteresis of Materials Under Influence of Torsional Bending Vibrations), O. Foeppl and G. Schaaf. Forschungsarbeiten auf dem Gebiete des Ingenieurwesens, no. 335, 1930, 27 pp., 54 figs. In tests at Woehler Institute of Braunschweig Institute of Technology, hysteresis values obtained with bending stress of test bars and with torsional stress are compared; as result deep insight is obtained into behavior of materials under alternating stresses; hysteresis is quite different for light metals than for other metals investigated.

Extrusion. The Extrusion of Metals—I, C. A. Colombel. Rolling Mill Jl., vol. 5, no. 5, May 1931, pp. 355–358, 4 figs. Flow of metals under pressure, dealing especially with early experiments which act as basis of modern extrusion methods.

Magnetic Hardening. Hardening Metals by Rotating Magnetic Fields, E. G. Herbert. Metallurgia, vol. 3, no. 18, and vol. 4, no. 19, Apr. and May, 1931, pp. 219–221, 8 figs., and 9–13, 17 figs. April: Author describes his discovery of remarkable changes produced in metals by action of rotating magnetic field; hardening of alloy steels; application to non-ferrous metals, such as duralumin, rod brass, and brass sheet. May: New developed magnetic phenomena is applicable to hardening of tools of any type or design; treatment occupies not more than two minutes at temperatures not exceeding 200 deg. cent.; data on experiment with alloy steels, duralumin, and brass; graphs indicating results and comparison with other hardening processes. Bibliography.

Wear Testing. Wear of Gauges, O. Nieberding. Metallurgist (Supp. to Engineer), May 29, 1931, pp. 71–73, 4 figs. Review of report issued by V.D.I. Verlag, Berlin, 1930, previously indexed, on wear of metals with special regard to measuring surfaces of gages, giving results of tests with apparatus consisting of rotating disk, connected with screw arrangement by means of which test piece is drawn radially across it, thus tracing out archimedean spiral; test piece is rod with end ground and lapped to radius of 36 mm.; results are compared in general way with those obtained by French and Herschman in their metal-to-metal tests.

MOLDING MACHINES

Jarring. A New Combination Jolt-Squeeze Machine. Foundry Trade Jl., vol. 44, no. 769, May 14, 1931, pp. 334 and 346, 4 figs. Molding machines, type URP, designed and built by Badische Maschinenfabrik, combine perfected labor-saving details in regard to jolting and squeeze molding, together with automatic turning over and lifting off; machines are built with lifting capacity of 5, 10, and 15 cwt. and are shockless during operation.

MOTOR TRUCKS

Krupp. Grossraum-Kraftwagen Flettner-Krupp (Flettner-Krupp Large-Volume Truck). Automobiltechnische Zeit., vol. 34, no. 4, Feb. 16, 1931, pp. 84–85, 2 figs.; see also brief translated abstract in Automotive Abstracts, vol. 9, no. 4, Apr. 1931, p. 99. New German 10-wheeler has 14-ton capacity; chassis is made up of engine cab and truck proper; power is transmitted from 150-hp., 6-cylinder Krupp engine through set of universal-joint coupled shafts to four rear wheels which do all driving; intermediate four wheels are steered automatically when cab changes direction; capacity is 13.7 tons.

Trailers. Heavy Road-Transport Trailer Engineering, vol. 131, no. 3411, May 29, 1931, p. 718, 3 figs., partly on p. 719. Trailer, manufactured by Herman Rueter, Langenhagen, near Hanover, consists of double framework with central well; ends are carried on truck each provided with eight wheels having double tires; weight is therefore distributed on total of 32 tires; suitable for transport of heavy machinery such as transformers and boilers.

N

NITRIDATION

Features of Process. An Appraisal of Nitriding, M. A. Grossmann. Am. Iron and Steel Inst.—Advance Paper, for mtg. May 22, 1931, 10 pp. Outstanding features of nitriding process; it seems reasonable to attribute hardness of nitralloy to presence of very finely agglomerated aluminum-nitrogen compounds dispersed in alpha iron; advantage in development of nitralloy, and applications where nitralloy is not suitable.

L'état actuel de la nitruration des produits métallurgiques (Present State of Nitridation Metallurgical Products), L. Guillet. Genie Civil, vol. 98, no. 20, May 16, 1931, pp. 489–495, 18 figs. Properties and susceptibility to nitridation of various steels; test results illustrate improvement of friction characteristics; advantageous application of nitrided steel for various industrial purposes; utilization of nitrided steel in machine construction, particularly of internal-combustion engines.

NON-FERROUS METALS

Fatigue Testing. Fatigue Tests in Shear of Three Non-Ferrous Metals, H. F. Moore and R. E. Lewis. Am. Soc. Testing Matls.—Advance Paper, no. 42, for mtg. June 22–26, 1931, 7 pp., 4 figs. Results of tests on copper, brass and duralumin; testing machines and test specimens used; fatigue tests were made in reversed flexure, reversed torsion, and with cycles of torsion varing from zero to maximum.

NOZZLES

Oil-Engine Fuel Injection. Development of an Impinging-Jet Fuel-Injection Valve Nozzle, J. A. Spanogle and G. T. Hemmeter. Nat. Advisory Committee Aeronautics—Tech. Notes, no. 372, Apr. 1931, 9 pp., 9 figs. on supp. plates. Design and testing methods of impinging jet nozzles for 2-stroke cycle engine with fuel-injection and spark ignition; two smooth jets impinging upon each other at angle of 74 deg. gave spray that can be carried along with air stream of comparatively low velocity or entrained with fuel jet from round-hole orifice.

O

OPEN-HEARTH FURNACES

Practice. A Thermal Study of an Open-Hearth Furnace, W. M. Henry and T. J. McLaughlin. Fuels and Furnaces, vol. 9, no. 6, June 1931, pp. 703–706 and 716. Purpose of particular study of open-hearth furnace operation was to obtain definite and accurate information of pressure, draft, temperature and volumetric conditions existing in furnace system. Before Am. Iron and Steel Inst.

P

PHOTOELASTICITY

Stress Investigation. Watching Stresses at Work. H. N. Blackmon. Machy. (N. Y.), vol. 37, no. 10, June 1931, pp. 737–742, 10 figs. Use of photoelastic methods by Westinghouse Research Laboratories for investigating stresses in moving or stationary parts; sketches illustrate stress distribution in celluloid models of notched bar, dove-tails, drawings, and gears.

PISTON RINGS

Leakage Testing. Leakage Tests of Piston-Rings, A. P. Petre. Soc Automotive Engrs.—Jl., vol. 28, no. 6, June 1931, pp. 685–686, 1 fig. Methods of testing piston rings for leakage at plant of American Hammered Piston Ring Co., one static test and other conducted under working conditions; results of both types of test on piston rings of different designs are given in table.

PLASTICITY

Measurement. Zur Frage der bildsame Verformung (Problem of Plastic Deformation), R. Mitsche. Stahl und Eisen, vol. 50, no. 47, Nov. 20, 1930, pp. 1645–1647, 3 figs ; see also Gummi-Zeitung, vol. 45, no. 29, Apr. 17, 1931, p. 1185, 3 figs. Simple and inexpensive method of testing plastic deformation is described, which permits direct observation of deformation processes also in interior of body.

PNEUMATIC MACHINERY

Varieties of. Performing Mechanical Operations by Pneumatic Devices, A. F. Clark. Machine Design, vol. 3, no. 5, May 1931, pp. 33–36, 8 figs. Practical examples illustrate successful application of pneumatic drive for opening and closing furnace doors, imparting rotary motion to mixers in concrete plant, in riveting machines, and earth boring machines; horsepowers and speeds of air motors at various pressures.

POWER GENERATION

Economics of. The Progress of Power Production, W. B. Woodhouse. Engineering, vol. 131, no. 3408, May 8, 1931, pp. 611–612. Reduction in consumption of coal is due to improved methods of using coal and development of alternative sources of power; ability of Great Britain to meet this change depends largely on progress that can be made in cheapening production of power from coal; changing economic relations between steam and water power; while water power competes with coal in supply of power requirements, oil fuel is rival in field of transport; factors which will govern success of British grid. Before Inst. Metals.

POWER-PLANT ENGINEERING

Research. Current Research in Power and Allied Fields. Power, vol. 73, no. 21, May 26, 1931, pp. 833–859. Tabulation of research projects in progress or completed during 1929, 1930, and 1931, by various industrial companies and universities throughout world listed under following headings: boilers, combustion, condensers, corrosion, electrical, feed water, fluid flow, fuels, heat transfer, heating and ventilating; internal combustion, lubrication, materials, steam prime movers, smoke and dust abatement, thermal water power, welding and miscellaneous.

POWER PLANTS

Gas Engine Vs. Steam Turbine. Essais comparatifs d'un groupe électrogène à gaz et d'un turboalternateur à vapeur (Comparative Tests of Gas-Engine Set and Steam Turbo-Alternator), M. Steffes. Chaleur et Industrie, vol. 12, no. 131, Mar. 1931, pp. 103–108, 15 figs. General considerations; acceptance tests of M.A.N. Schneider 2500-kw. gas engine and of A.E.G. turbo-alternator of 6000/9000 kw., both recently installed in metallurgical plants; results show thermal superiority of gas engine over steam turbine, for types and sizes investigated.

PRESSURE VESSELS

Manufacture. Heavy Plate Construction, W. D. Walcot. Contract Rec., vol. 45, no. 20, May 20, 1931, pp. 587–589, 3 figs. Developments that have taken place in methods of building structures of heavy plates such as steam accumulators, penstocks, etc.; design; bevel planing; sub-punching and reaming; shop work; flanging; fitting; riveting.

Welding. Demonstration Test of a Welded Steel Tank at Brantford. Can. Machy., vol. 42, no. 11, May 28, 1931, pp. 38, 40 and 42, 6 figs. Waterous, Ltd., Brantford, Ont., carried out test on tank constructed of flange-quality boiler plate, one-half inch thick; joints were all of butt-type welded with quasi-arc uranium-alloy electrodes; measurements were made while tank was under pressure up to 1200 lb. per sq. in.; results obtained are tabulated.

Heavy Steel Fabricating Plants, O. Adams. Welding, vol. 2, no. 5, May 1931, pp. 326–331, 13 figs. Welding methods and equipment required in manufacture of pressure vessels and storage tanks in Houston plant of Wyatt Metal & Boiler Works; table of procedure on plate using automatic welding machine with multiple head.

PROTECTIVE COATINGS

Tarpon Metal. Tarpon-Metallisierung und Heissluft-Verfahren (Tarpon Metal Coating and Hot-Air Process), G. Kutscher. Verkehrstechnik, no. 6, Feb. 6, 1931 (supp.), pp. 82–83, 1 fig. According to this process, rust is removed from metal first with sand blast, after which patented liquid containing metal is applied, preferably with spraying pistol; liquid is mixture of heat-resisting lacquer with metallic powder, such as aluminum; sprayed coating is heated by means of hot-air blower; advantages and properties of this tarpon coating.

PULVERIZED COAL

Combustion of. Processus de la combustion du charbon pulvérisé (Combustion of Pulverized Coal), A. Grebel. Académie des Sciences—Comptes Rendus, vol. 192, no. 9, Mar. 2, 1931, pp. 567–569, 1 fig. Study of heating and oxidation of pulverized coal; it is definitely established that carbon monoxide is formed primarily, contrary to prevalent theory of primary total oxidation of carbon in form of carbon dioxide.

PUMPING PLANTS

Air Chambers. Bemessung des Windkessels bei selbsttaetigen Pumpenanlagen (Dimensioning of Air Chambers in Automatic Pumping Plant), A. v. Okolicsanyi. V.D.I. Zeit., vol. 75, no. 21, May 23, 1931, pp. 657–660, 12 figs. Factors controlling size of air chamber and method determining shortest switching time on which proper dimensioning of air chamber is based.

PUMPS

Air-Lift. A Vitreosil Air Lift Pump, B. Moore. Indus. Chemist, vol. 7, no. 76, May 14, 1931, pp. 201–202, 2 figs. System consists essentially of two connected tubes to form "U" tube with unequal branches; there are two types of air-lift pumps: pulsating type, in which aerated column consists of pistons of liquid, more or less separated by bubbles; emulseur type, in which aerated column consists of homogeneous mixture of liquid with very small bubbles of gas; details of small vitreosil air-lift pump of emulseur type, constructed in fused silica.

Centrifugal. Centrifugal Pumps Operated Under Abnormal Conditions, C. P. Kettredge. Power, vol. 73, no. 22, June 2, 1931, pp. 881–884, 3 figs. Results of tests to determine effects of water hammer in discharge line of centrifugal pump when suddenly stopped, by cutting off power or by rotor's being fouled by obstruction.

Pulsometer. Verbesserungen am Pulsometer (Improvements in Pulsometers), L. Klein and R. Focke. Foerdertechnik und Frachtverkehr, vol. 24, no. 1, Jan. 2, 1931, pp. 1–2, 1 fig.; see also brief translated abstract in Power Engr., vol. 26, no. 301, Apr. 1931, p. 156. Pulsometer pump is useful where heating of liquid by condensed steam can be utilized to advantage, as in laundries, dye, and bleach-works, breweries, etc.; tests show that delivery of pump increases and specific steam consumption decreases as frequency of pulsations is increased; investigations are being continued with view to improving capacity and economy by facilitating delivery of pump.

R

RAIL MOTOR CARS

Storage-Battery. Automotrices Electriques à accumulateurs en Europe (Electric Storage Battery Operated Rail Motor Cars in Europe), P. Lo Balbo. Industrie des Voies Ferrees et des Transports Automobiles, vol. 25, no. 291, Mar. 1931, pp. 90–105, 24 figs. Advantages of storage batteries, operation based on experiences in northern Italy; data on equipment, routes, cost of operation, etc., of principal Italian lines; graphs illustrate electrical performance characteristics.

RATCHET DRIVES

Design. Ratchet Feed With Link Motion Adjustment, H. E. Kitchen. Machy. (N. Y.), vol. 37, no. 10, June 1931, pp. 755–756, 1 fig. Design of ratchet mechanism meeting following conditions: rate of feed changeable without stopping machine; pawl terminates feeding stroke in same angular position; after four complete revolutions feeding movement ceases for interval and pawl engages same notch on final movement.

REFRIGERATING COMPRESSORS

Compound. Verbundkompressoren in der Kaelte-Industrie (Compound Compressors in Refrigerating Industry), H. Freund. Zeit. fuer die Gesamte Kaelte-Industrie, vol. 38, no. 4, Apr. 9, 1931, pp. 50–55, 10 figs. How problems of compound-compressor construction were solved by firm of A. Borsig; special feature of single-stage compressors are retained in multiple-effect types; examples of single, double-, and triple-stage ammonia compressors, carbon-dioxide compressor, vertical ammonia compound compressor, etc.

ROLLING MILLS

Sheet Mills. Neue Aufreissmaschine fuer Feinbleche (New Separating Machines for Fine Sheets), F. Christ. Stahl und Eisen, vol. 51, no. 21, May 21, 1931, pp. 648–649, 3 figs. New machine developed by Demag, Duisburg, permits continuous separation of double sheets which have stuck together in packs after cooling.

ROLLS

Failures of. Fatigue Stresses With Special Reference to the Breakage of Rolls, F. Bacon. S. Wales Inst. Engrs.—Proc., vol. 47, no. 2, Apr. 10, 1931, pp. 141–255, and (discussion) 256–335, 28 figs. Reference is made to previously indexed paper by J. S. Caswell; whenever freshly fractured faces of broken roll exhibit hair-crack markings, fracture is described as fatigue fracture; effect of temperature on fatigue strength; curves presented make it easy to evaluate stress ratios corresponding to hair-crack markings on broken rolls. Bibliography. Abstract of this paper has been previously indexed under classification of Rolls, Cast Iron.

S

SAND, FOUNDRY

Properties. Steel Foundry Molding Sands and Facings, A. S. Nichols. Am. Foundrymen's Assn.—Preprint, no. 31–25, for mtg. May 4–7, 1931, 13 pp., 6 figs. In interest of better understanding of steel foundry facing-sand mixtures, with particular reference to characteristics and functions of binder ingredients, Illinois Clay Products Co. sent questionnaire to 50 steel foundries in Central States; answers were returned by executives of 22 foundries, with total normal tonnage of 17,120 tons per month; tabulation of data received.

SAWS

Metal-Working. Scies circulaires modernes a grande puissance pour le débitage a froid des métaux (Modern High Power Circular Saw for Cold Cutting of Metals). Technique Moderne, vol. 23, no. 8, Apr. 15, 1931, pp. 247–251, 15 figs. Design and performance of various types and makes including Heller, Wagner, Burckhardt and Weber; sketches illustrate attachment and shape of cutting blades.

SCREW THREADS

Hobbing. Threading With a Hob, M. W. Seavey. Am. Mach., vol. 74, no. 20, May 14, 1931, pp. 759–761, 5 figs. Fundamental principles of internal thread cutting with particular regard to set-up of equipment; tables give data on hob speeds and feeds in relation to tensile strength; formula for computing cost.

SHAFTS AND SHAFTING

Electric-Generator Straightening. Straightening a Large 30-in. Generator Shaft, A. S. Robertson. Elec. News, vol. 40, no. 11, June 1, 1931, pp. 31–32, 2 figs. 320-ton Queenston rotor shafts was straightened by applying heat with coal oil burner and "kink" was measured to plus or minus 0.002 in. by comparatively simple method.

Stresses. Der Einfluss von Querbohrungen auf. die Biegungsschwingungsfestigkeit (Influence of Cross-Holes on Bending Vibration Resistance), H. Doering. Metall Wirtschaft, vol. 9, no. 38, Sept. 19, 1930, pp. 781–786, 14 figs. Results of tests to determine reduction in endurance by cross-holes in cylindrical bars, such as are often indispensable in engine construction; influence of 7.2-mm. cylindrical holes in bars of 24 mm. diam. is shown for different materials; influence of corner effect and elimination of stress concentration.

Torsional Stresses, With Plastic Shear, E. Abt. Engineering, vol. 131, no. 3412, June 5, 1931, p. 721, 4 figs. Experimental solutions of torsion problems; attempt is made to take into consideration fact that limiting shearing stress, hitherto assumed as constant, is linearly increasing with extension after yield point has been reached;